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SECURITY INFORMATION

CONFIDENTIAL

THIRTY-SEVENTH

PROGRESS REPORT

OF

THE FIRESTONE TIRE & RUBBER COMPANY

ON

BATTALION ANTI-TANK PROJECT

UNDER

Contract Nos. DA-33-019-ORD-33
DA-33-019-ORD-1202

ORDNANCE DEPARTMENT PROJECTS

TS4-4020—WEAPONS AND ACCESSORIES

TM1-1540—AMMUNITION

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COPY No. 4

THE FIRESTONE TIRE & RUBBER COMPANY
Defense Research Division
Akron, Ohio

AUGUST 1953

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THIRTY-SEVENTH

PROGRESS REPORT

OF

THE FIRESTONE TIRE & RUBBER CO.

ON

BATTALION ANTI-TANK PROJECT

Contract Nos.
DA-33-019-ORD-33 (Negotiated)
DA-33-019-ORD-1202

RAD Nos. ORDTS 1-12383
ORDTS 3-3955
ORDTS 3-3957
ORDTA 3-3952

THE FIRESTONE TIRE & RUBBER CO.
Defense Research Division
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ABSTRACT

The Weapon System - A 90mm BAT weapon system is being manufactured. The ONTOS mount and remote control firing system, manufactured by Firestone, has been delivered to Aberdeen Proving Ground and is being tested.

T119 Projectile - Spin rate data for T119 projectiles, reported in the Thirty-Fifth Progress Report, have been reduced and an equation of roll is developed.

Two experiments concerned with increasing the initial spin rate of the T119E11 projectile in order to improve stability during the initial part of the trajectory, are reported. In one study rubber obturating rings were used and in the other study gilding metal rotating bands were used. Test arrangements and resulting data are reported.

Twenty T119E11 projectiles, prepared and assembled so as to represent extremes (loose or tight) in clearance between certain components of the tail assembly, were tested for mechanical functioning and accuracy. The test conditions are charted and illustrated and the data discussed.

A tail assembly, .475 in. shorter than the standard tail assembly (fin length remaining the same),were fired for accuracy tests. The data are presented.

T171 Projectile - Two modifications of the T171 projectile were fired for accuracy and flight evaluation at Erie Ordnance Depot. The test results are given.

Using the Siacci theory and experimental data, ballistic coefficients for four T171 configurations were determined. The form factor, drag coefficient, terminal velocity, time of flight and elevation were found for various ranges and muzzle velocities for the four configurations. The results are analyzed.

Penetration Studies - Two separate but related scaling studies of penetration have been completed. The first part of the study was reported previously and the second portion is described here and the data from both studies are summarized.

Tests were conducted concerning spin rate behavior of DRB398 cones at high spin rates,penetration behavior of zinc alloy (Zamak 3) cones, effect of tee configuration on penetration. Data for the tests are presented.

Ten M344 (T119E11) prototype projectiles were withdrawn from production and modified for static penetration tests. The test data are given.

Fuzes - Functioning tests were conducted with T267E14 base elements and with T223 E2 fuzes. The test data are presented.

Manufacturing Summary - A summary of rifles, mounts and projectiles manufactured by Firestone under the subject contracts is given.

THE WEAPON SYSTEM

Ultimate BAT System

The 90mm ultimate BAT weapon system, illustrated and discussed in the Thirty-Sixth Progress Report, is being manufactured. The rifle will be mounted on the T152E7 aluminum mount for preliminary tests. A mount and tripod for the 90mm weapon is being designed.

ONTOS Mount and Firing System

The mount and remote control firing system for the ONTOS vehicle, developed by this division and illustrated in the Thirty-Sixth Progress Report, was delivered to Aberdeen Proving Ground during August. There was some delay in getting the system mounted on a vehicle and no test firing was done until the last week in August. Test results are incomplete at this time and will be reported later.

Future Program

1. Continue the manufacture of the 90mm ultimate BAT rifle.

2. Complete the preliminary design of a 90mm mount.

3. Investigate designs for improved firing effort on BAT rifles.

4. Continue tests of ONTOS firing system.

Derivation of Roll Motion Equation From Experimental Data

The Thirty-Fifth Progress Report presented spin data for five rounds of T119E11 projectiles. These data have been reduced (using a method suggested by Bolz and Nicolaides in BRL Report No. 711) and an equation of roll for the T119E11 projectile has been derived.

The dynamical equation of roll is

$$\phi' = S - C_1 A e^{-C_1 z} \qquad (1)$$

where z = distance down range (ft)

ϕ' = rate of roll (deg/ft)

S = steady state rolling velocity (deg/ft)

C_1 = damping constant

A = arbitrary constant.

Since S, C_1 and A may be determined experimentally it is not difficult to establish a relationship between spin rate and distance throughout the entire trajectory of a projectile.

The experimental data for one projectile, X368 (Thirty-Fifth Progress Report), are used in this study. A plot of rotation versus range is presented in Fig. 1. In plotting the curve of Fig. 1 an arbitrary figure (329) was subtracted from each of the measured angles to insure that the curve, when extrapolated back to the muzzle, could be contained in the graph. From this plot a table of values for ϕ' is determined by computing $\frac{\Delta\phi}{\Delta z}$ in intervals of 20 ft. The resulting values are given in Table I and a graph of ϕ' (rate of roll) versus z (distance from gun) appears in Fig. 2.

Determination of S

An initial value of S, denoted S_o, may be calculated from the graph of ϕ' versus z by the relation

$$S_o = \phi_1' + \sum_{i=2}^{n} \Delta\phi_i' \qquad (2)$$

$$\text{where } \frac{\Delta\phi_n'}{\Delta\phi_{n-1}'} = e^{-C_1 \Delta z} = \text{constant.}$$

A table of data to establish this constant ratio is,

Z	ϕ'	$\Delta\phi'$
0	.290	
		.980
150	1.270	
		.600
300	1.870	

The ratio, therefore, is $\frac{.600}{.980} = .6122$.

Values of $\Delta\phi'$ for distances greater than the length of the measured range are extrapolated and are tabulated below:

z	ϕ	$\Delta\phi'$
0	0.290	
		0.980
150	1.270	
		0.600
300	1.870	
		0.367
450		
		0.224
600		
		0.137
750		
		0.084
900		
		0.051
1050		
		0.031
1200		
		0.019
1350		
		0.012
1500		
		0.007
1650		
		0.004
1800		
		0.002
1950		
		0.001
2100		

From the above table

$$\phi_1' + \sum_{i=2}^{15} \Delta\phi_i' = 2.809 = S_o .$$

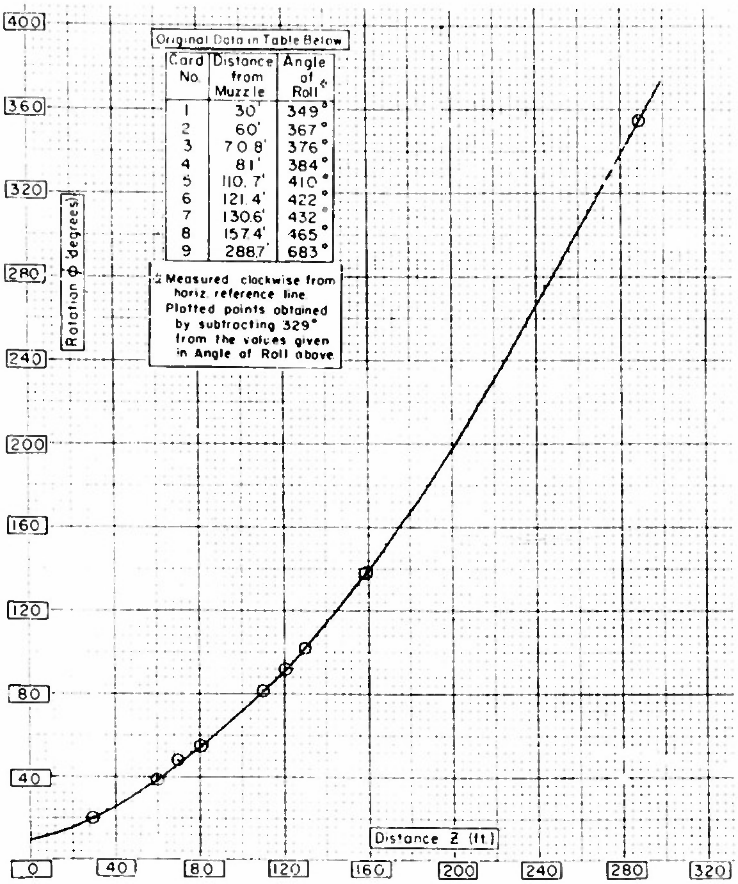


Fig. 1. Roll Angle Versus Distance From Gun.
T119E11 Projectile No. X368.

Table I
Values of ϕ'
Determined From Experimental Roll Data
T119E11 Projectile No. X368

Z (ft)	ϕ (°)	$\Delta\phi$	ϕ' (°/ft)
0	8.9		
10		7.0	.350
20	15.9		
30		9.9	.495
40	25.8		
50		12.6	.630
60	38.4		
70		15.1	.755
80	53.5		
90		17.6	.880
100	71.1		
110		20.1	1.005
120	91.2		
130		22.5	1.125
140	113.7		
150		25.4	1.270
160	139.1		
170		27.8	1.390
180	166.9		
190		29.5	1.475
200	196.4		
210		33.0	1.650
220	229.4		
230		34.9	1.745
240	264.3		
250		36.8	1.840
260	301.1		
270		37.2	1.860
280	338.3		
290		37.0	1.850
300	375.3		

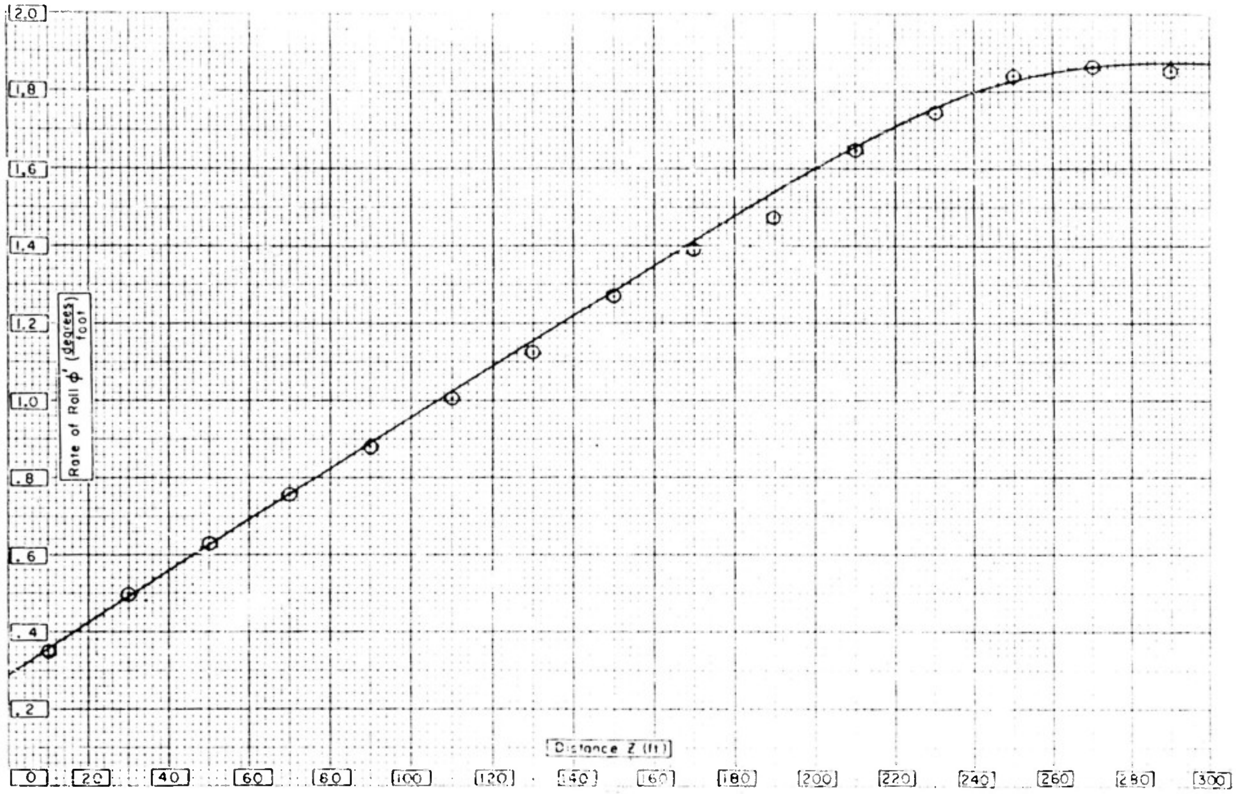


Fig. 2. Rate of Roll Versus Distance From Gun.
T119E11 Projectile No. X368.

Determination of C_1

Equation (1) may be written in the form

$$\ln(S_o - \phi') = \ln(C_{1_o} A) - C_{1_o} Z \quad , \quad (3)$$

where C_{1_o} is an initial value of C_1 . A logarithmic plot of $(S_o - \phi')$ versus Z is given in Fig. 3. It can be seen that the slope of the straight line is $-C_{1_o}$; thus,

$$C_{1_o} = \frac{\ln 2.519 - \ln .939}{300} = .002870 .$$

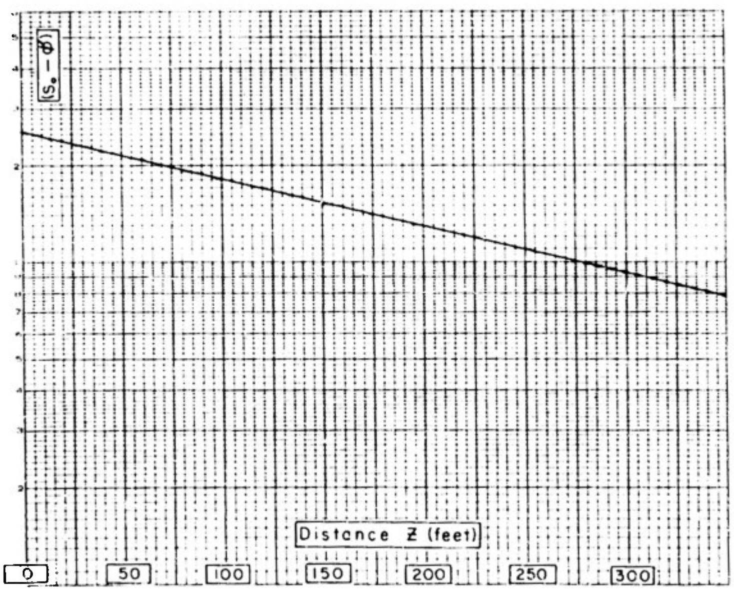


Fig. 3. $(S_o - \phi')$ Versus Distance.
(Logarithmic Plot.)

Determination of A

A set of boundary conditions for (1) is $Z = 0$, $S = S_o$, $C_1 = C_{1_o}$, $\phi' = \phi'_1$ and $A = A_o$. Thus,

$$A_o = \frac{(S_o - \phi'_1)}{C_{1_o}} = 877.8.$$

Roll Motion Equation

The roll motion equation with initial values for S, C and A is

$$\phi' = 2.809 - 2.519\, e^{-.002870 Z} \quad (4).$$

These parameters can be determined more precisely by the method of "Differential Corrections", but for the approximation sought here it is sufficient to use initial values. Table II is a table of values for equation (4) in which ϕ' is converted to revolutions per second. Fig. 4 is a graph of ϕ' (rps) versus Z for the entire range.

The magnitude of spin, as here found, appears reasonable when compared with spin measurements of the T119E11 projectile as reported by Frankford Arsenal in Report No. R-1086.

Table II
Projectile Spin (rps)
Determined From Roll Motion Equation

Z (ft)	ϕ' (°/ft)	u (ft/sec)	ϕ' (rps)
0	.290	1685	1.36
110	.972	1667	4.50
210	1.430	1648	6.55
250	1.580	1635	7.18
300	1.744	1627	7.88
600	2.359	1569	10.28
1200	2.729	1457	11.05
1600	2.775	1384	10.67
2400	2.806	1247	9.72
3000	2.809	1152	8.99

Fig. 4. Rolling Velocity Versus Distance From Gun.
Calculated From Roll Equation For T119E11 Projectile.

Studies of Launching Conditions (Increasing Initial Spin Rate)

Spin measurement data for the T119E11 projectile, described in the preceding section of this report, indicate that the projectile emerges from the muzzle with a spin rate of one or two revolutions per second. It has been observed in flight photographs that the fins of the T119E11 projectile do not open fully until the projectile has traveled five to seven feet from the muzzle. (Thirty-Sixth Progress Report). It is possible that the projectile is sensitive to perturbations in this interval before the canted fins begin to induce stabilizing spin.

Increasing the spin at the muzzle would tend to minimize the effects of perturbations in that region and ultimate accuracy might then be improved. The most serious limitation on the increased initial spin is the ability of the fin assembly to withstand the increased stress.

In contemplating higher spin rates the degrading effect of spin on penetration must be considered. It can be shown that a large initial spin will damp out quickly by applying the differential equations of motion to an initial spin rate of 40 rps. Fig. 5 shows that even this high spin rate will damp out at 400 ft to slightly less than 22 rps, which would not cause a prohibitive degradation in penetration.

Rubber Obturating Rings

A simple method to increase the muzzle spin rate of a projectile is to place on the projectile a plastic or rubber type rotating or obturating band which would slip or grind away sufficiently to give a reasonable spin. This method has been tried with two projectiles equipped with rubber "O" rings placed in a special machined groove in the chamber as shown in Fig. 6.

The rotation (in degrees) for the two projectiles, as measured with yaw cards,

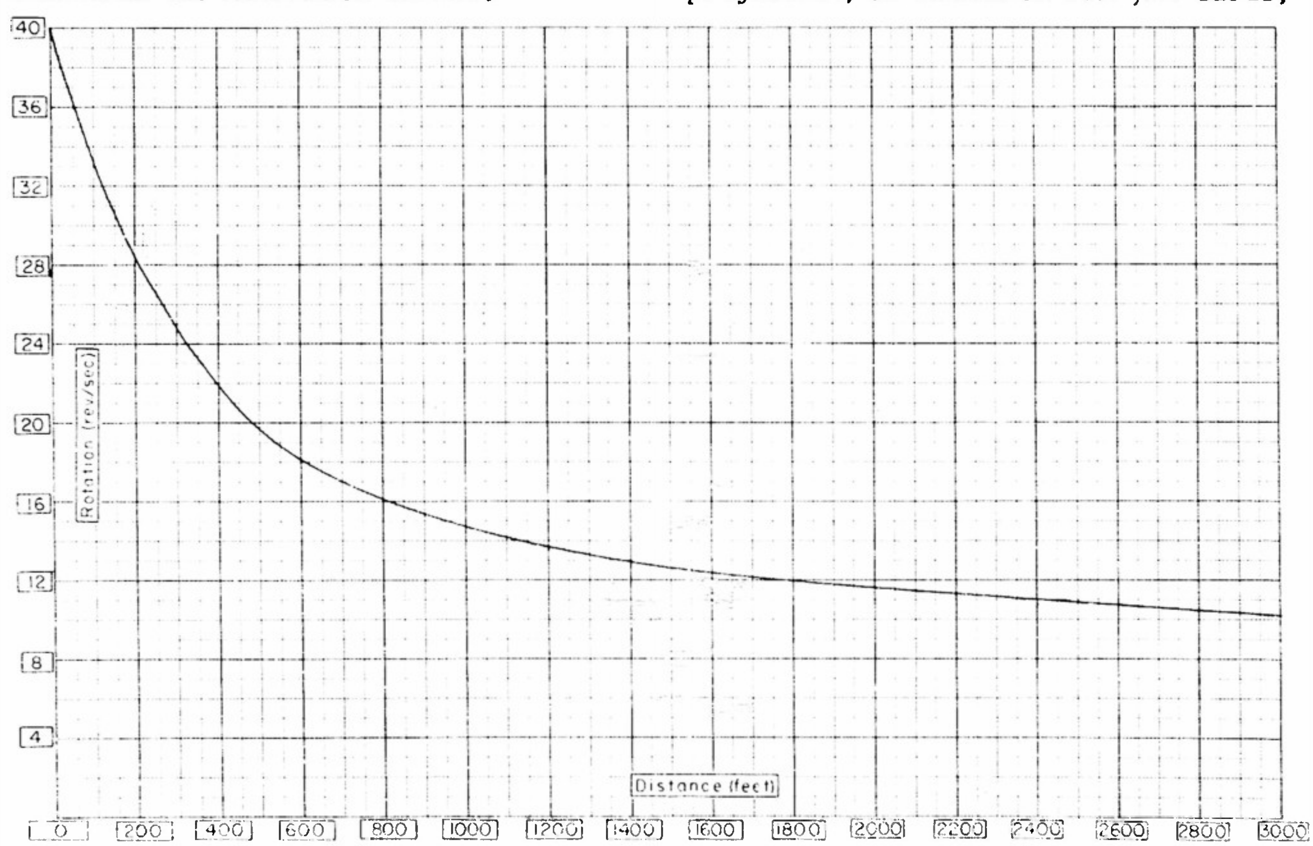


Fig. 5. Calculated Spin Behavior.
T119E11 Projectile Launched With High Initial Spin.

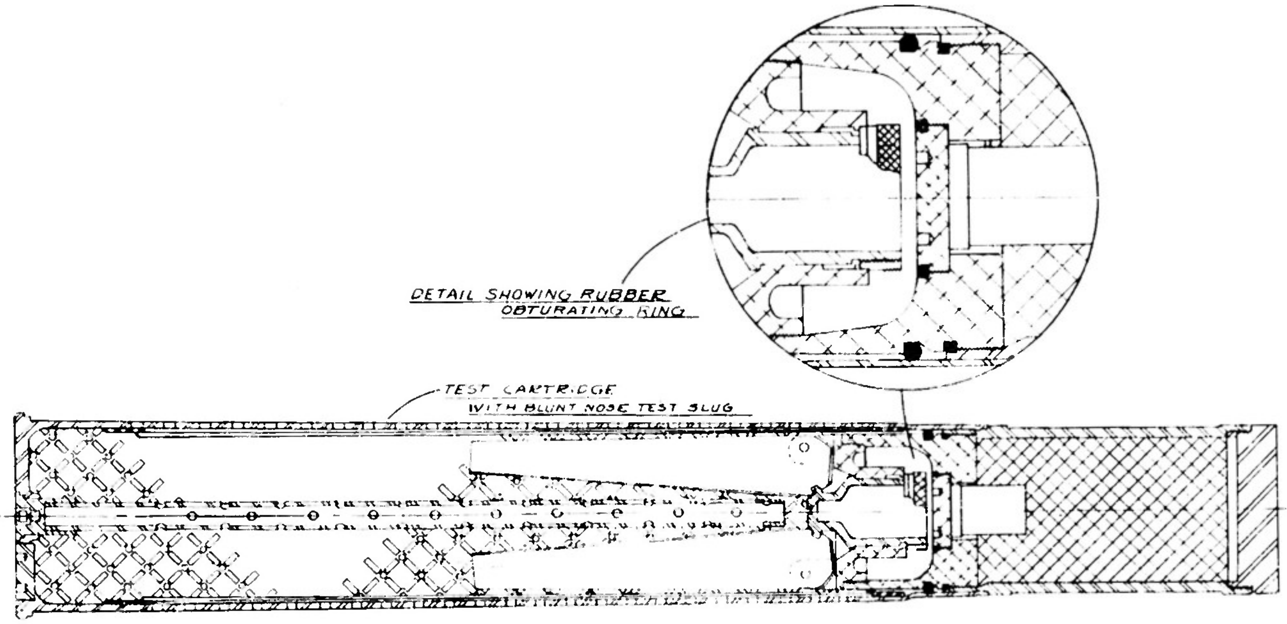


Fig. 6. Rubber Obturating Ring.
In Position in Groove On T119E11 Projectile.

is contained in the firing record, Table III, and a plot of rotation versus distance is shown in Fig. 7. The calculated spin rates at various distances are given in Table IV and are compared with corresponding spin rates for the standard T119E11 projectile in Fig. 8. The original range data for the standard T119E11 projectile used in this comparison are found in Table VI of the Thirty-Fifth Progress Report and a preceding section of this report.

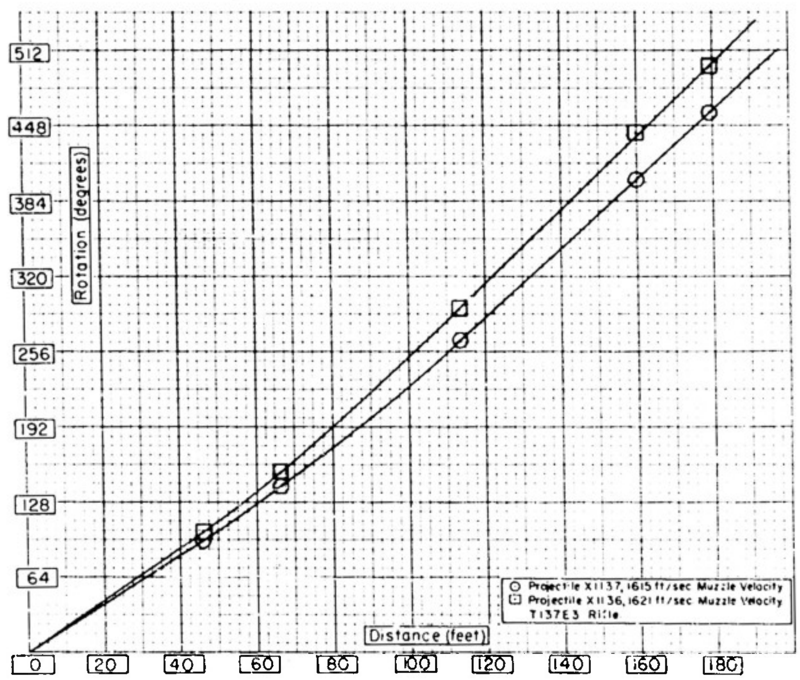


Fig. 7. Rotation Versus Distance From Muzzle.
T119E11 Projectiles With Rubber Obturator Rings.

Table III
Range Data
T119E11 Projectiles With Rubber Obturators

Date of Test Aug 21, 1953

Purpose of Test Obturator Test

PROJECTILE
Model T119
Type E11
Weight 17.5 lbs (Nom.)
C.G. Location ____
Bourrelet Dia 4.132 -.002 in.
Special Features Blunt nose w/rubber obturator

TEST GUN
Model T137E3
Type 105mm recoilless
Serial No 4
Chamber 8444-11-B
Bushing (Vent) 22B-374-66
Tube —
Sighting Equipment M17 Elbow Telescope
Mount
Type Pendulum
Constant 2.48 lb/sec-in.
Solenoid Mechanical Firing System

MISCELLANEOUS DATA
Range Recovery Box
Propellant
Type M10 MP Web .0335 in Weight 7 lb 1 oz.
Lot No PA 30252
Primer M57
Shell Case T53E1
Liner ORC-545, 4.65 oz./yd²
Temperatures
Magazine
Max 78°F Min 70°F Present 75°F
Loading Room 78°F Ambient ____

Round No	Proj. No.	Proj Weight (lb.)	Powder Charge (lb-oz)	Piezo Pressure	Chamber Pressure (lb/sq in)	Muzzle Velocity ft/sec Instr.	Muzzle Velocity ft/sec Actual	Elev (mils)	Azimuth (mils)	Position of Hit Vert	Position of Hit Horiz.	Corrected Position of Hit — mils Vert	Corrected Position of Hit — mils Horiz	Recoil (in.)	Observations
5646	X1137	—	7-1	12,714	11,300 11,400	1570	1615	—	—	—	—	—	—	1½ R.	Obturating ring missing, small particles found
5647	X1136	—	7-1	13,082	10,800 11,300	1576	1621	—	—	—	—	—	—	2 R	Obturating ring missing, small particles found
	Note: Rounds were loaded and fired as single units.														

Yaw Card & Screen Distances

|— 46.66' — Card 1 — 19.67' — 1st Coil, Card 2 — 47.25' — Card 3 — 46.75' — 2nd Coil, Card 4 — 18.75' — Card 5

Distance	*Angle of Rotation (deg.) X1137	X1136
46.66'	296.4	181.3
66.33'	342.0	231.3
113.58'	460.0	369.8
160.33'	604.0	520.3
179.08'	660.5	580.0

* measured clockwise from vertical reference line

Proof Director E. Huffman
Observers V. E. Lucas
L. Swaetly, R. Walters
Signed ____

Table IV
Effect of Rubber Obturator On Spin
T119E11 Projectile

Distance (feet)	Projectile X1137			Projectile X1136		
	$\frac{d\phi}{dz}$ (°/ft)	u (ft./sec.)	Spin (rps)	$\frac{d\phi}{dz}$ (°/ft)	u (ft./sec.)	Spin (rps)
0	1.94	1615	8.71	--	1621	--
60	2.40	1591	10.61	2.70	1597	11.98
80	2.58	1583	11.34	2.85	1589	12.58
100	2.76	1575	12.08	3.00	1581	13.18
120	2.88	1567	12.54	3.18	1573	13.89
140	2.94	1559	12.73	3.27	1565	14.22
160	3.00	1551	12.93	3.30	1557	14.27
180	3.00	1543	12.86	3.33	1549	14.33

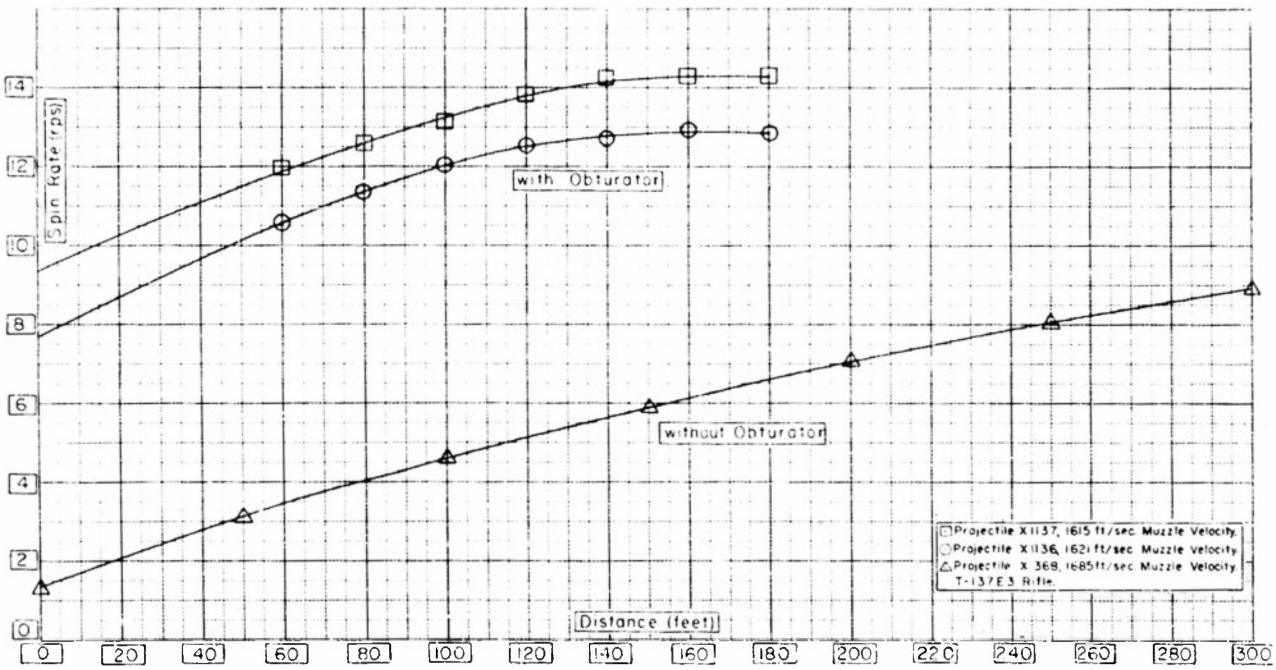


Fig. 8. Comparison of Spin Rates.
Projectiles With and Without Rubber Obturators.

It is evident from Fig. 8 that the launching spin of the rubber obturated projectiles (approximately nine revolutions per second) is considerably higher than for the unobturated T119E11 projectile (approx. 1.3 rps). The recovered projectiles were in good condition, indicating that the increased spin had not damaged the fins. Small bits of the rubber "O" ring had been forced into the gap between the body and chamber, by the propellent gases.

In view of the satisfactory performance of these two rounds it is planned to fire a complete program to determine the effect of higher launching spin rate upon accuracy and to establish the consistency of the muzzle spin of a rubber obturated round.

Gilding Metal Rotating Bands

Another method of increasing initial spin is through the use of a gilding metal rotating band. The Twelfth Progress Report included the results of firing three projectiles with gilding metal rotating bands from a tube rifled one turn in 480 calibers. The projectiles suffered severe damage in the tail assembly. Since the tail assembly of the T119E11 projectile is considerably stronger than the tail assembly of the test above it was decided to test the ability of the T119E11 tail assembly to withstand the sudden torque transmitted to the body by the action of a gilding metal rotating band in the rifling of the tube.

Two projectiles, one with fins 6.92 in. long and one with standard length (8.92 in.) fins were fired from a 1-480 tube, through a series of yaw cards, into a recovery box. The range data are given in Table V, which includes the measured rotation. A plot of rotation versus distance appears in Fig. 9. Values of spin rate (rev/sec) versus distance are given in Table VI and the tabulated values are plotted in Fig. 10.

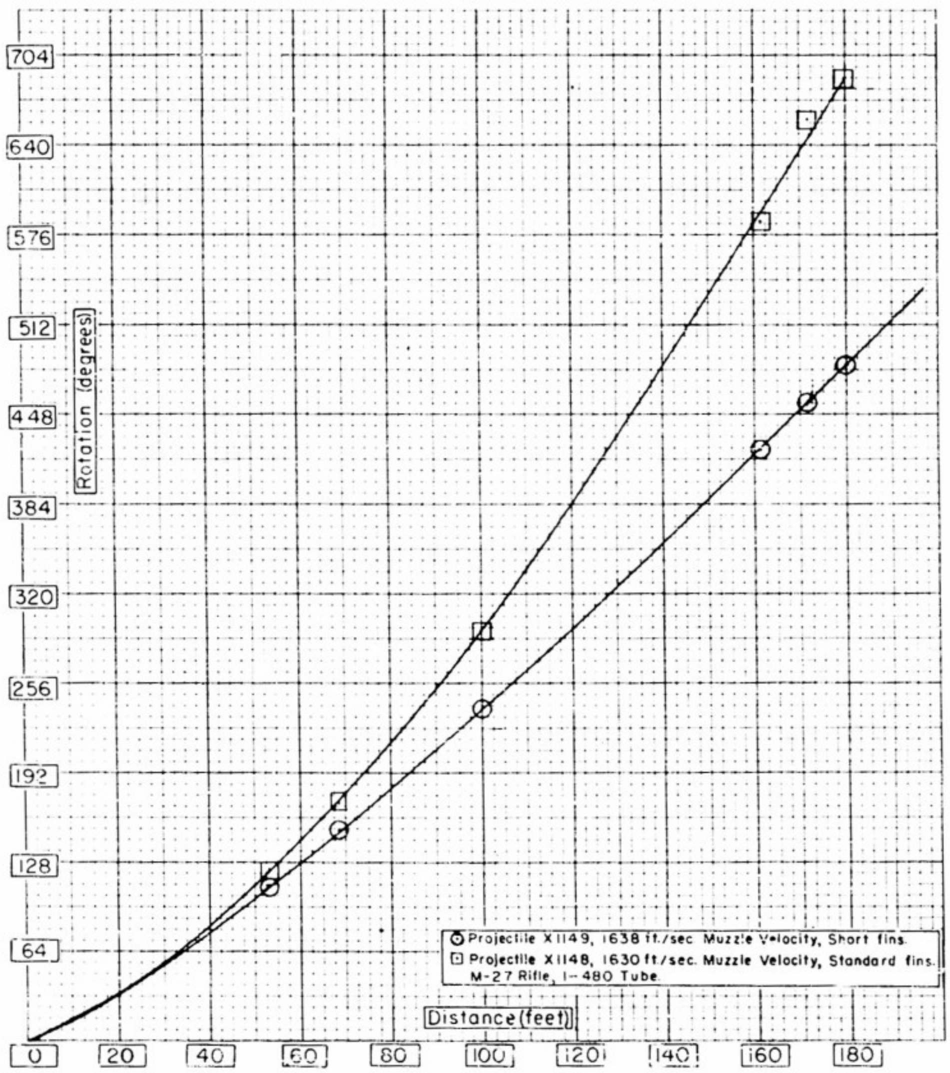


Fig. 9. Rotation Versus Distance From Muzzle.
T119E11 Projectiles With Gilding Metal Rotating Bands.

Table V
Range Data
T119E11 Projectile With Rotating Band Fired From 1-480 Tube

Purpose of Test Charge Development & Spin Measurement
Date Aug 25, 1953

PROJECTILE
Model T119
Type E11
Weight 17.52 lb (Nom)
C.G. Location
Bourrelet Dia 4.132 -.002 in.
Special Features Bluntnose w/rotating band

TEST GUN
Model M-27
Type 105mm recoilless
Serial No #397
Chamber #7230827
Bushing (Vent) VA893, #7230826
Tube 2590-3-12433, #159, 1-480 Twist
Sighting Equipment M17 mod Telescope
Mount
Type Pendulum
Constant 2.64 lb/sec/in

MISCELLANEOUS DATA
Range Recovery Box
Propellant
Type M10 MP Web .0335 in Weight Varies
Lot No PA 30252
Primer M-57
Shell Case T-53E1
Liner DRC-545
Temperatures
Magazine
Max 76°F Min 71°F Present 76°F
Loading Room 80°F Ambient 96°F

Round No	Proj. No.	Proj Weight (lb.)	Powder Charge (lb-oz)	Recoil (in.)	Chamber Pressure (lb/sq in)	Muzzle Velocity ft/sec Instr	Muzzle Velocity ft/sec Actual	Elev (mils)	Gage Number M-3	Position of Hit Vert	Position of Hit Horiz	Corrected Position of Hit — mils Vert	Corrected Position of Hit — mils Horiz	Recoil (in.)	Observations
5683	X1015		8 0	19½ R	8200 8200	1549	1595		9190 10182						
5684	X1007		8 4	19 R	8600 8200	1586	1632		8176 246						
5685	X1149	17.5	8 4	19½ R	9100 8600	1592	1638		10628 5328						Misfired, fired as operating handle was moved
5686	X1148	17.5	8 4	20 R	8000 8200	1584	1630		11831 9394						

Notes: Projectile X1149 (short fins) recovered in good condition, fins undamaged, no yaw on cards
Projectile X1148 (standard fins). Yaw cards indicated bent fins, from 5-10° yaw

Angle of Rotation*		
Distance	X1149	X1148
53.08'	314.5°	191.0°
68.41'	351.8°	238.0°
100.49'	436.5°	359.5°
161.95'	621.4°	652.0°
172.99'	657.9°	725.0°
180.03'	681.0°	752.8°

* Measured in degrees clockwise from vertical reference line.

Yaw Cord Distances

Gun — 53.08' — 1 — 15.33' — 2 — 32.08' — 3 — 61.46' — 4 — 11.04' — 5 — 7.04' — 6 Recov. Box

Screen Distances

68.42' — 93.58'

Proof Director E. Huffman
Observers C. M. Cox, E. R. Berus
Signed O. Miller

Table VI

Spin Rate of T119E11 Projectile

With Rotating Band; Fired From 1-480 Tube

Distance (feet)	Projectile X 1149			Projectile X 1148		
	$\frac{d\phi}{dz}$ (°/ft.)	u (ft./sec.)	Spin (rps)	$\frac{d\phi}{dz}$ (°/ft.)	u (ft./sec.)	Spin (rps)
0	--	1638	--	--	1630	--
60	2.43	1614	10.89	3.09	1606	13.78
80	2.61	1606	11.64	3.72	1598	16.51
100	2.79	1598	12.38	4.23	1590	18.68
120	2.91	1590	12.85	4.62	1582	20.30
140	3.06	1582	13.45	5.10	1574	22.30
160	3.18	1574	13.90	5.46	1566	23.75
180	3.30	1566	14.36	5.70	1558	24.67

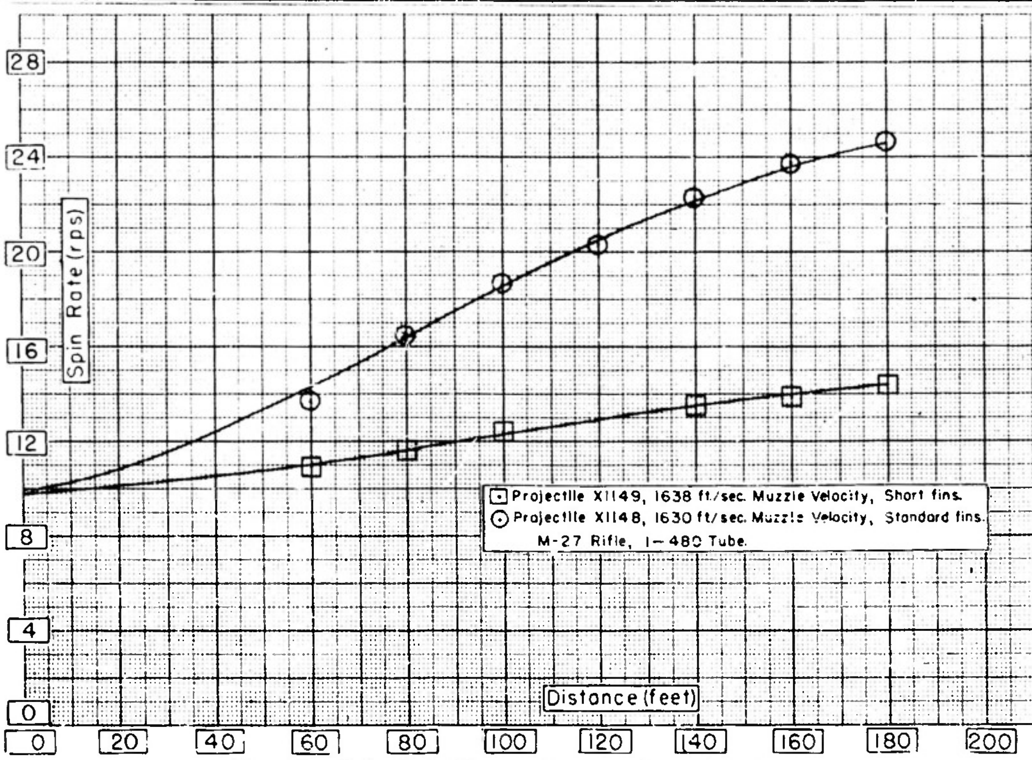


Fig. 10. Spin Rate Versus Distance From Muzzle.
T119E11 Projectiles With Gilding Metal Rotating Bands.

The spin of the projectile with fins 6.92 in. long was normal but the projectile with standard length (8.92 in.) fins attained an abnormally high spin rate of 24.5 rps at 180 feet. It is believed that this high spin rate was due to fin distortion, giving an abnormal cant to the fins.

From these test results it is evident that the results of launching a T119E11 projectile with a non-slip rotating band from a low spin tube are considerably less satisfactory than the results from launching the same projectile with a slip band from a high spin tube. The fins were damaged by the high initial angular velocity when using the non-slip band and the low spin tube. On the basis of these test results no additional tests from slow spin tubes are planned.

Performance Tests of T119E11 Projectile

Effect of Dimensional Variations

Twenty T119E11 projectiles, prepared and assembled so as to represent extremes (loose or tight) in clearance between certain components of the tail assembly were tested for mechanical functioning and accuracy. These tests were so made that manufacturing tolerances might be as broad as is justifiable.

Fig. 11 illustrates the tail components involved in the dimensional study and Table VII charts the original and proposed tolerances. The parts were machined for this test and Table VIII is an inspection report of the parts. The firing record for the twenty projectiles is given in Table IX.

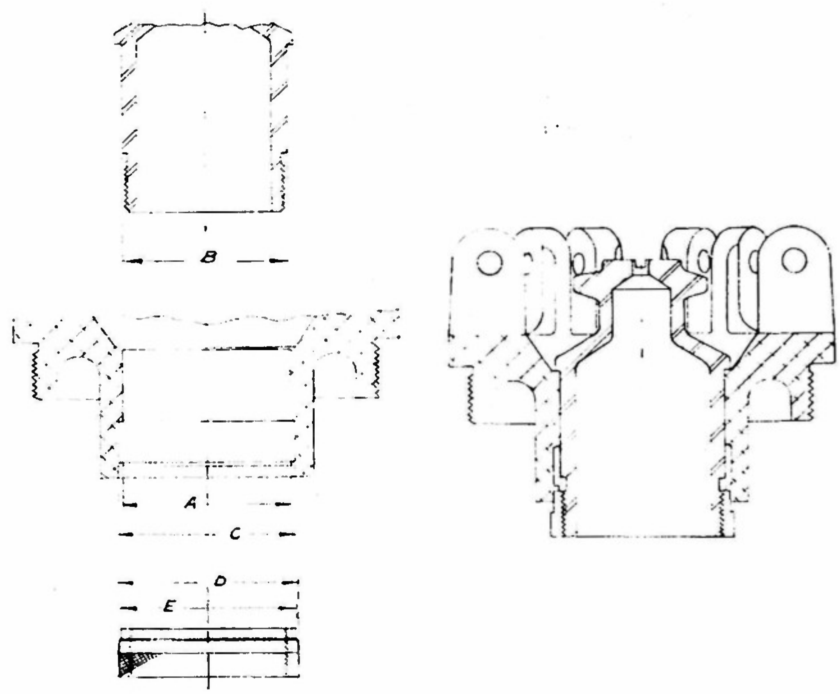


Fig. 11. T119E11 Tail Assembly Components.
For Tolerance Study.

Table VII
Proposed Dimensional Changes
Tolerance Study

Dimension	T119E11 Dimensions	Proposed Dimensions
A	1.6875 + .0010	1.687 + .004
B	1.6860 - .0015	1.686 - .002
C	1.810 + .001	1.810 + .004
D	1.817 - .001	1.819 - .002
E	1.809 - .002	1.809 - .002

Table VIII
Inspection Data
T119 Projectile Parts

Projectile No	DIMENSIONS (in) A	B	C=1.810 +.0002 Max	Min	D=1819 - 0002 Max	Min	E=1 809 - 0002 Max	Min.
SET I								
X867	SEE		1.8125		1.8191	1.8181	1.8094	1.8083
X868	NOTES		1.8135		1.8200	1.8191	1.8099	1.8093
X869	BELOW		1.8120		1.8200	1.8191	1.8102	1.8100
X870			1.8101		1.8205	1.8181	1.8103	1.8085
X871			1.8125		1.8200	1.8187	1.8099	1.8093
X872			1.8115		1.8207	1.8191	1.8101	1.8088
X873			1.8125		1.8202	1.8194	1.8107	1.8102
X874			1.8090		1.8198	1.8188	1.8095	1.8092
X875			1.8120		1.8194	1.8182	1.8103	1.8093
X876			1.8095		1.8200	1.8194	1.8100	1.8097
SET II			C=1.814 +.0002		D=1 817- .0002		E=1807 - 0002	
			Max	Min	Max	Min	Max	Min
X877			1.8142	1.8140	1.8181	1.8177	1.8082	1.8080
X878			1.813[illegible]		1.8188	1.8175	1.8092	1.8085
X879			1.8142	1.8140	1.8176	1.8171	1.8074	1.8070
X880			1.8125		1.8176	1.8172	1.8085	1.8080
X881			1.8160		1.8178	1.8161	1.8070	1.8055
X882			1.8135		1.8169	1.8153	1.8075	1.8060
X883			1.8120		1.8182	1.8179	1.8087	1.8085
X884			1.8142	1.8140	1.8165	1.816	1.8075	1.8070
X885			1.8142	1.8140	1.8177	1.8172	1.8083	1.8079
X886			1.8115		1.8178	1.8167	1.8083	1.8075

Notes:
1. Dimension A = 1.691 + .000[illegible]. All pieces in tolerance.
2. Dimension B = 1.684 - .0002. Eighteen pieces in tolerance, two measured at 1.6836.
3. SET I is close clearance group; Set II is loose clearance group.

Four of [illegible] projectiles were fired through [illegible] yards, into a recovery box. Two [illegible] the four projectiles were from Group II (loose clearance) of Table VIII and were [illegible] to give excess pressures at [illegible] temperature. The other two projectiles from Group I (close tolerance) [illegible] VIII were loaded for operating [illegible] and conditioned at -40° F. These temperature limits represent [illegible] extremes to "looseness" and "tightness" [illegible] The [illegible] yards and the recovered projectiles gave evidence of normal functioning [illegible] assemblies in all four projectiles.

[illegible] ght pr[illegible] Group I (close tolerance) and [illegible] II (loose tolerances) of Table VIII were fired for accuracy at a range of 998 yards. The first projectile flew over the target and after resetting the elevation the next fifteen rounds all hit the target with probable errors of dispersion of V.P.E.= ±.49 mil and H.P.E.=±.51 mil.

Since these projectiles were prepared from certain components machined so as to create extremes of fit wider than any fit that could be expected in production manufacture and assembly, the results of the firing tests indicate that tolerances in the tested components may be relaxed to the proposed degree presented in Table VII without being detrimental to the accuracy of the projectile.

Table IX
Range Data
T119E11 Projectile
Effect of Relaxed Tolerances

Date of Test August 12, 1953

Purpose of Test To test effect of relaxing tolerances on tail assembly
Program #42

PROJECTILE
Model T119
Type E11
Weight 17.52 lb (Nom.)
C.G. Location —
Bourrelet Dia 4.132 in. -.002
Special Features Relaxed Tolerances On Tail Assembly

Screen Distances: Gun — 66.46' — 1 — 93.84' — 2 — 18.5' — Recov Box; Gun — 75.46' — 1 — 98.20' — 2

SET I - Close Clearance
SET II - Loose Clearance

Solenoid Mechanical Firing System

TEST GUN
Model T137E2
Type 105 mm Recoilless
Serial No
Chamber 1K679
Bushing (Vent) GA637
Tube 22-B-849-C (1-20)
Sighting Equipment Direct Sight M62E4 #18006, Mount T153 #9, Gunners Quadrant .13243
Mount PC-2 48 #
Type Pendulum; Mt on Concrete Base
Serial T152E4

1 mil = 39.93 in

Corrected to 21 mils elev & 1 mil Azimuth

MISCELLANEOUS DATA
Range Recovery Box & 948 yds Target 28°E of Mag North
Propellant
Type MPM10 Web .0336 Weight Varies
Lot No PA30239
Primer T81
Shell Case T53
Liner DRC 497
Temperatures
Magazine
Max 77°F Min 70°F Present 76°F
Loading Room 80°F Ambient 87°F

Round No	Proj. No.	Proj. Weight (lb.)	Powder Charge (lb-oz)	Wind Vel. & Dir. mph deg*	Chamber Internal Pressure (M.C.Cu) (lb/sq in.)	Muzzle Velocity ft/sec Instr.	Muzzle Velocity ft/sec Actual	Elev (mils)	Azimuth (mils)	Position of Hit (inches) Vert	Position of Hit (inches) Horiz.	Corrected Position of Hit — mils Vert.	Corrected Position of Hit — mils Horiz.	Recoil (in.)	Observations	Horiz Pos of Hit Corrected To O Az	Normal Wind Comp
5549	ogive X876	17.50	7-12½	SET I	8000 8000	1505	1527	(Time idg approx 1½ min	Fired into recovery box)		Projectile Recovered Broken Up Fin Assy OK.			SET I 4R	Cold box -41°F 81°F Ambient at Firing		
5550	ogive X874	17.51	7-12½	SET I	7200 7400	1515	1537	(Time idg approx 1 min	Fired into recovery box)					SET I 1R	Cold box -41°F		
5551	blunt nose X881	17.48	8-5	SET II	10800 11600	1725	1770	Fired	into recovery box					SET II 3¼R			
5552	blunt nose X879	17.52	8-5	SET II	12000 12000	1711	1756	Fired	into recovery box					SET II 2¼R			
5553	X868	17.54	7-12½	7-255°	9600 10000	1643	1667	6-2-24	2L	missed	target			SET I	Good flight 1 mil high over center		
5554	X880	17.51	7-12½	10-275°	9000 10200	1665	1679	6-2-22	2L	+86	-17½	+1.394	+.515	SET II	Good flight	+1.617	3
5555	X871	17.52	7-12½	7-245°	9800 9800	1652	1676	-21	2L	+54½	+23	+1.517	+1.642	SET I	Good flight	+2.641	4
5556	X878	17.51	7-12½	13-245°	8400 10200	1661	1685	5.7-21	2L	-32½	-36	-.905	0	SET II		+1.001	8
5557	X869	17.52	7-12½	13-235°	9800 10400	1644	1668	5.7-22	2L	+42½	-51	+.183	-.417	SET I	Good flight	+.584	6
5558	X885	17.52	7-12½	15-230°	4800 9800	1656	1679	5.7-22	2L	+97½	-83	+1.715	-1.308	SET II	" "	-.306	6
5559	X875	17.52	7-12½	9-225°	10200 10000	1643	1667	22	1L	+48½	-18	+.350	-.501	SET I	" "	+.501	3
5560	X877	17.52	7-12½	7-230°	9200	1653	1677	22	1L	+38	-19	+.058	-.529	SET II	Slight precession noted	+.473	3
5561	X870	17.50	7-12½	6-220°	10200 10200	1646	1668	22	1L	+29	+2	-.193	+.057	SET I	Good flight	+1.058	1
5562	X884	17.52	7-12½	10-240°	10600 10800	1653	1677	22	1L	+79	-11½	+1.199	-.320	SET II	Good flight	+.682	5
5563	X867	17.53	7-12½	7-250°	10200 10200	1649	1673	21	1L	+16	-3½	+.445	-.097	SET I	Good flight	+.904	5
5564	X883	17.52	7-12½	5-260°	10400 10600	1645	1669	21	1L	+13	-2	+.362	-.057	SET II	T52 cut liner Slight precession	+.[illegible]	4
5565	X872	17.52	7-12½	9-250°	10600 7600	1625	1649	21	1L	-3½	+37	-.097	+1.030	SET I	" " " Good flight	+2.032	6
5566	X882	17.52	7-12½	7-260°	10400 9000	1645	1669	21	1L	+14	-18½	+.390	-.515	SET II	" " " Good flight	+.487	6
5567	X873	17.52	7-12½	9-280°	9800 9400	1649	1673	21	1L	+41	-32½	+1.141	-.905	SET I	" " " Good flight	+.097	3
5568	X886	17.52	7-12½	8-235°	No Gages	1651	1675	21	1L	+20	+18	+.557	+.501	SET II	" " " Good flight	+1.503	4
				Ave Press Rd 5553-5568	9834	Ave Acc Rds.	1672										

NOTES: (1) Proj. X881 & X879 The ogives were removed & blunt noses were used.
(2) Proj. X874 not recovered. Projectiles X876, X881 & X879 were recovered. No apparent damage was noted.
(3) Recovered projectiles taken to Akron for examination.
(4) On rounds 5549, 5550, 5551 & 5552 yaw cards were placed on the coils & front of recovery box.

Center of Impact V = +.541 mil; H = -.060 mil
Probable Error — Vertical ±.489 mil
Probable Error — Horizontal ±.505 mil

* Clockwise from Magnetic North

H Positions Corrected to 1 mil Left

Proof Director E. Huffman
Observers F. Mendez, P. Dake
Signed O. Miller

With A Short Chamber-Tail Assembly

A tail assembly, .475 in. shorter than the standard tail assembly of the T119E11 projectile has been tested at Erie Ordnance Depot. Fig. 12 illustrates the revised shorter chamber and tail assembly.

Six projectiles incorporating the shorter tail assembly were fired through yaw cards into a recovery box. The firing record is contained in Table X. Three of the six rounds were loaded to give excess pressures at ambient temperature; three were loaded for operating pressures, and prior to firing were conditioned in a cold box at -40°F. The yaw cards showed that the fin-opening mechanism functioned satisfactorily and the recovered projectiles gave no evidence of failure or malfunction of any of the components.

Fourteen projectiles with the short tail assembly were fired for accuracy at an 18 ft by 18 ft target at a range of 998 yards. The data appear in Table XI. Probable errors of dispersion for 14 impacts were V.P.E.=±.39 mil and H.P.E.=±.60 mil.

These test results indicate that the short tail assembly can be incorporated into the T119 projectile if, at some future time, a desired decrease in length and weight justifies the change.

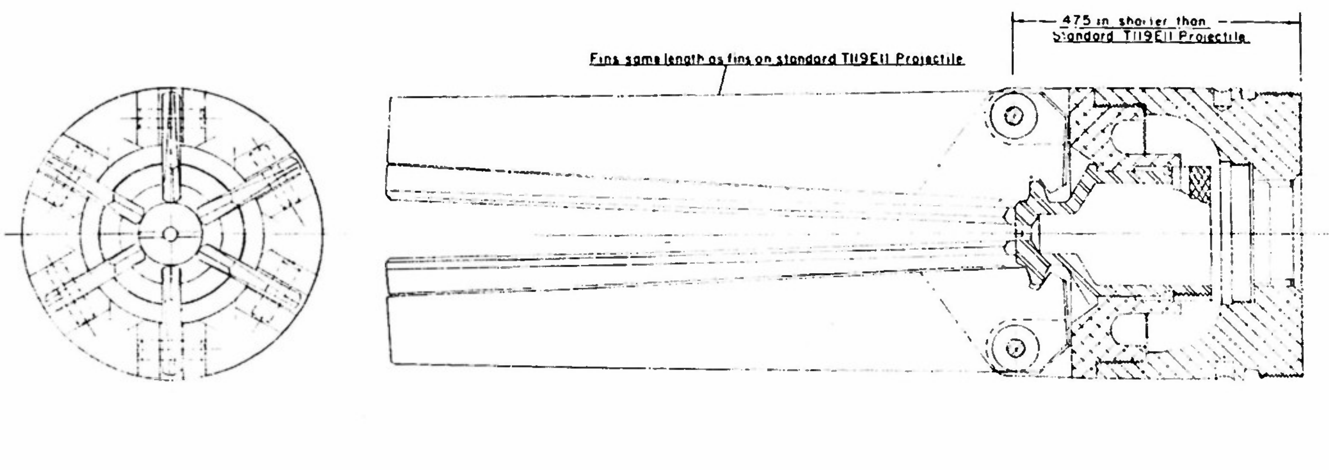


Fig. 12. Short Chamber and Tail Assembly.

Table X
Range Data
T119 Projectile With Short Tail Assembly

Date of Test July 22 1953

Purpose of Test To Test T119(Ex) with Short Tail Assy

PROJECTILE

Model T119

Type Experimental

Weight —

C.G. Location —

Bourrelet Dia. 4.132 ±.002 in

Special Features Short Tail Assy DRC 560

Gun — 29.75' — 36.42' — 94.75' (Yaw Card Distances 1, 2, 3)

66.17' — 94.75' (Screen Distances)

TEST GUN

Model T137E3

Type 105 mm Recoilless

Serial No #28

Chamber 23C-1201

Bushing (Vent) 22C-2090

Tube 22B-849-C

Sighting Equipment M17 Adapted Elbow Telescope

Mount

Type Pendulum Mount

Serial PC = 2.06 lb-sec/in

MISCELLANEOUS DATA

Range Recovery Box

Propellant PA30239

Type MPM10 Web .0335 Weight 8 lb 4 oz

Lot No PA30239

Primer M-57

Shell Case T53E1

Liner DRC 545 (3.0 oz/yd² Rayon)

Temperatures

Magazine

Max 77°F Min 71°F Present 73°F

Loading Room 74°F Ambient 75°F

Round No	Proj. No.	Proj. Weight (lb.)	Powder Charge (lb-oz)	Recoil (in)	Chamber Pressure (lb/sq in)	Muzzle Velocity ft/sec Instr	Muzzle Velocity ft/sec Actual	Shell Type	Gage No M-3	Position of Hit Vert	Position of Hit Horiz	Corrected Position of Hit — mils Vert	Corrected Position of Hit — mils Horiz	Recoil (in)	Observations
5348-1	X 801	17.52	8-4	2 1/4 R	12500 / 12300	—	—	Blunt Nose	8126 / 17052	4 Fin Mark at 10° & 10 o'clock					1/8" x 1/4" piece of liner in case. Chamber clean
5349-2	X 793	17.42	8-4	2 1/4 R	11600 / 12900	1720	1765	"	11331 / 5328	No Fin Marks					1/8 x 5/8 " " " " " Chamber clean
5350-3	X 795	17.52	8-4	2 1/8 R	12400 / 12400	1737	1782	"	246 / -47	2 Fin Marks at 11 o'clock 1" & 3/4"					3/8 x 1 1/2 " " " " " "
5351-4	X 805	17.54	7-13 1/2	1 F	9100 / 8600	1551	1573	Ogive	5192 / 11218	No Fin Marks		1/8" x 3/4" piece of liner in case			Cold Rounds At -40°F T119(Ex) With Ogive
5352-5	X 790	17.54	7-13 1/2	1 1/2 F	8200 / 8500	1573	1595	"	8665 / 9132	No Fin Marks		Piece of liner came out with projectile			No 1 Yaw Card 3/8" x 3/8" piece of liner
5353-6	X 789	17.54	7-13 1/2	0	9400 / 8800	1571	1503	"	17418 / 17236	No Fin Marks		Piece of liner came out with projectile			Piece of liner 1/8" x 1 1/4"

NOTES:

Projectiles X793, X795, X805, X790 & X789 recovered for examination. Proj X801 went out of box down range.

The small sections of liner, rayon with polyethylene burned off, were all found in the shell case.

Inspection of the tube and chamber after each round showed only small fragments of shattered propellent.

After the fourth round a section of the top of the liner (DRC 545) was found a few feet from the muzzle.

After the fifth and sixth rounds a similar section was found close to the muzzle.

Evidence indicates (groove & lands marks) that this section of liner was between projectile and tube wall, obviously acting as an obturator.

Atmospheric conditions prevented Fastax pictures.

Round	Yaw Card Measurements Card #1	Card #2	Card #3	Fin Measurements Card #1	Card #2	Card #3	
1	4 1/8" x 4 1/16"	4 1/8" x 4 1/8"	4 1/8" x 4 1/8"	11 1/2 x 11 1/8 x 11 1/8	11 1/8 x 11 1/8 x 11 1/2	10 3/4 x 10 3/4 x 10 3/4	
2	4 1/8" x 4 1/8"	4 1/8" x 4 1/8"	4 1/8" x 4 1/8"	11 1/8 x 11 1/8 x 10 7/8	11 x 11 1/8 x 11	10 3/4 x 10 3/4 x 10 3/4	
3	4 1/8" x 4 1/8"	4 1/8" x 4 1/8"	4 1/8" x 4 1/8"	11 1/8 x 11 1/8 x 11	11 1/4 x 11 x 10 7/8	10 3/4 x 11 x 10	
4	4 1/8" x 4 1/8"	4 1/8" x 4 1/8"	4 1/8" x 4 1/8"	10 7/8 x 11 x 11	10 5/8 x 10 3/4 x 10 7/8	10 5/8 x 10 3/4 x 10 7/8	
5	No card	4 1/2" x 4 1/2"	4 1/8" x 4 1/2"	No card	10 1/2 x 10 3/4 -	10 3/8 x 10 1/2 x 9 1/2	Cards not numbered. First stand fell before round was fired.
6	4 1/8" x 4 1/8"	4 1/8" x 4 1/8"	4 1/8" x 4 1/8"	10 7/8 x 11 x 11	10 3/4 x 11 1/8 x 10 7/8	10 3/4 x 10 3/4 x 10 3/4	

Proof Director E. Huffman

Observers E. Clark, F. Mendel, J. Rubins, G.L. Marsh

Signed O. Miller

Table XI
Accuracy Range Data
T119 Projectile With Short Tail Assembly

Date of Test Aug 4, 1953

Purpose of Test Accuracy of T119(E2) With Short Tail Ass'y
Program #31

PROJECTILE

Model T119
Type Experimental
Weight (Nom.) 17.52 lb.
C.G. Location —
Bourrelet Dia. 4.132 in. -.002
Special Features With short tail assembly (DRC560)
Retardation Factor = .195 ft/sec/ft
Solenoid Mechanical Firing System

Screen Distances: 66.42' — 1 — 93.75' — 2; 63.0' — 105.75'

TEST GUN

Model T137E2
Type 105mm Recoilless
Serial No —
Chamber 1K679
Bushing (Vent) GB637
Tube 22B-270-P M42E4 #18006
Sighting Equipment T138 mt. #9
Gunner Quadrant M1 #113243
Mount
Type T152E4
Serial #13 (Concrete base) Pendulum Mount - PC - 248 lb sec/in
Corrected to 0 Azimuth & 24 mils Elevation

MISCELLANEOUS DATA

Range 98 yds. Line of fire 28° E of Mag. North
Propellant
Type MPM10 Web .0335 Weight 7 lb-12½ oz
Lot No PA 30239
Primer T81
Shell Case Polyethylene & Rayon Sleeve
Liner —
Temperatures
Magazine
Max 77°F Min 71°F Present 74°F
Loading Room 71°F Ambient 91°F

Round No	Proj. No.	Proj. Weight (lb.)	Powder Charge (lb-oz)	Wind Vel. & Dir. (Clockwise from Mag. N)	Chamber Pressure (piezo) (lb/sq in.)	Muzzle Velocity ft/sec Instr.	Muzzle Velocity ft/sec Actual	Elev (mils) Zero Sup	Azimuth (mils)	Position of Hit (inches) Vert	Position of Hit (inches) Horiz.	Corrected Position of Hit — mils Vert.	Corrected Position of Hit — mils Horiz.	Recoil (in.)	Observations	Normal Wind Component
5491	X955	17.50	7-12½	—	14,292	1641	1663	fired down range for recoil check					11,200* 10,600	7¾ R	Tube 22C-444-0 (1-20)	—
5492	X960	17.51	7-12½	—	14,155	1642	1664	fired down range for recoil check					11,800 11,200		Cases bulged near gas seal	—
5493	X806	17.54	7-12½	30-210°	—	1647	1670	6-24	2L	+74	-35½	+2.060	+1.016		Fin mark at (3 o'clock) muzzle Good flight	1
5494	X796	17.55	7-12½	18-210°	13,550	1645	1668	-24	3L	+50½	-7	+1.046	+2.811		Good flight	.6
5495	X792	17.55	7-12½	18-225°	11,792	1600	1623	-24	3L	+20	-27½	+0.557	+2.186		Good flight	5.3
5496	X791	17.53	7-12½	18-210°	—	1616	1639	-24	3L	+54½	-34	+1.517	+2.060		Good flight	.6
5497	X788	17.54	7-12½	13-220°	12,001	1624	1647	-24	3L	+39½	-35½	+1.099	+2.018		Good flight	2.7
5498	X794	17.54	7-12½	17-205°	12,375	1645	1668	-24	3L	+77	-51½	+2.143	+1.573		Slight corkscrew effect	-.9
5499	X796	17.65	7-12½	17-230°	12,100	1628	1651	-24	3L	+55	+36	+1.531	+4.008		Good flight	4.4
5500	X798	17.55	7-12½	13-195°	12,104	1631	1654	6-24	3L	+60½	-84½	+1.684	+0.654		Fin mark at 10 o'clock muzzle 6" in Tube Good flight	-2.9
5501	X800	17.54	7-12½	22-215°	—	1627	1660	-24	3L	+92½	-72	+2.574	+1.002		Good flight	2.7
5502	X797	17.54	7-12½	15-205°	—	1641	1664	-24	3L	+60	-17	+1.670	+2.533		Fin mark at (12 30 o'clock) muzzle 1" long Good flight	-.8
5503	X799	17.50	7-12½	15-230°	12,691	1656	1679	-24	3L	+91½	-15½	+2.547	+2.074		Slight Yaw	5.6
5504	X804	17.51	7-12½	18-225°	12,655	1635	1658	-24	3L	+77½	-22½	+2.157	+1.880		Slight Yaw	5.3
5505	X802	17.60	7-12½	18-210°	12,547	1633	1656	-24	3L	+68½	0	+1.906	+3.006		Erratic Flight	.6
5506	X803	17.54	7-12½	16-225°	12,547	1631	1654	-24	3L	+52	-17½	+1.447	+2.519		Good flight	4.4

NOTES: *(1) Internal M-3 Cu pressures for rounds 5491 & 5492 (only ones taken). Proj. were T119 (blunt nose)
(2) Round 5505 & 5506 fired through one yaw card on the first coil. Gun was set with a horizontal reference line

Round	Body Yaw	Fin Marks	Round	Body Yaw	Fin Marks	
5494	4¼ x 4⅞	11⅛ x 11 x 11⅛	5500	4⅞ x 4⅞	10⅞ x 11 x 10¾	Measurements at target
5495	4½ x 4⅞	11 x 10¾ x 10¾	5503	5 x 4⅞	10¾ x 11 x 10¾	
5498	4⅞ x 4½	11⅛ x 11 x 11⅛	5504	5 x 4⅞	10⅞ x 10⅞ x 10¾	
5499	4¼ x 4⅞	10⅞ x 10⅞ x 10⅞	5506	4¼ x 4⅞	11 1/16 x 11 x 11⅛	

Root Mean Square
Center of Impact V = +1.710 mils; H = +2.17 mils
Probable Error — Vertical ±.387 mil
Probable Error — Horizontal ±.601 mil

Proof Director E. Huffman
Observers C.M. Cox, F. Mendez
L. Swaboly

Signed O. Miller

Future Program

1. A nylon slip-band will be tried as a means of increasing the muzzle spin of the projectile.

2. Twenty projectiles with rubber "O" ring obturators have been fired for spin and accuracy. The results will be reported in next month's publication.

3. Fifteen projectiles with short bodies, short ogives and rounded nose caps are being assembled. It is planned to fire these projectiles to check drag and accuracy.

4. Twenty special housings with an O.D. of 4.118 - .005 are still in process. This design should permit a smoother launching condition of the projectile. Results will be included in a later report.

Accuracy Tests

Two modifications of the T171 projectile were fired for accuracy and flight evaluation at Erie Ordnance Depot. Seven T171 MD8 rounds (Fig. 13) and twelve T171 MD10 rounds (Fig. 14) were launched from a T137 rifle having a 1-20 twist tube. The target, 18 ft. by 18 ft., was placed 1000 yards from the gun muzzle. Since the projectiles did not have rotating bands, it is estimated, from spin measurements previously made, that the rounds were rotating 2 to 3 rps at the muzzle.

T171MD8 (Fig. 13)

Of seven rounds of this modification fired one round hit the target. This one round, fired at an elevation of 23 mils and zero azimuth, with a muzzle velocity of 1692 feet per second, hit .28 mil below and 1.28 mils right of the aiming point. Two rounds, after hitting velocity coils, exhibited large yaw during the remainder of their observed flight and another round tumbled at a point about 600 yards down range. The remaining three rounds appeared stable in flight, but drifted off the line of sight. The firing record for this program is in Table XII.

A yaw card was placed on the first velocity screen and the three projectiles which flew badly (X902, X903, X911) each had a large initial yaw, indicating that poor launching conditions were responsible for the poor flight. The poor launching conditions may be related with the riding surface of the fins - which is narrower and longer than that of the T-4 fin used on the T171 MD10 projectile.

T171MD10 (Fig. 14)

Eleven of the twelve MD10 rounds fired hit the target, with probable errors of ±.60 mil horizontally and ±.90 mil vertically. The dispersion chart is shown in Fig. 15. These rounds, fired at an elevation of 23 mils and zero azimuth, with an average muzzle velocity of 1669

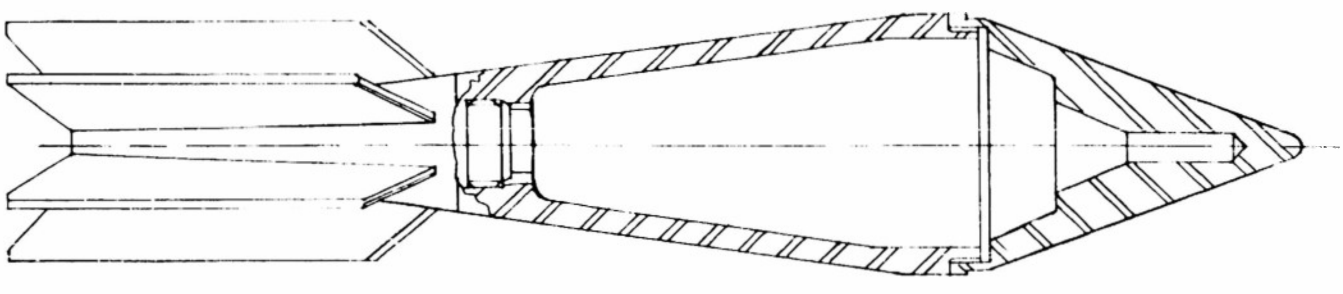


Fig. 13. T171MD8 Projectile.

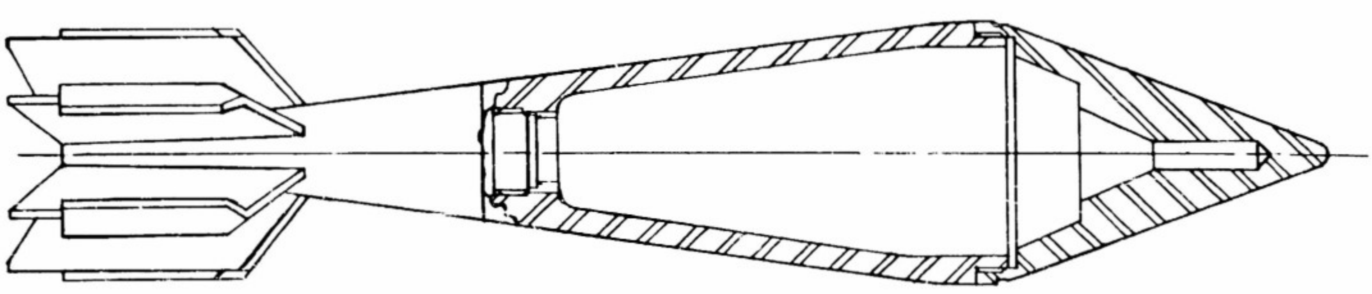
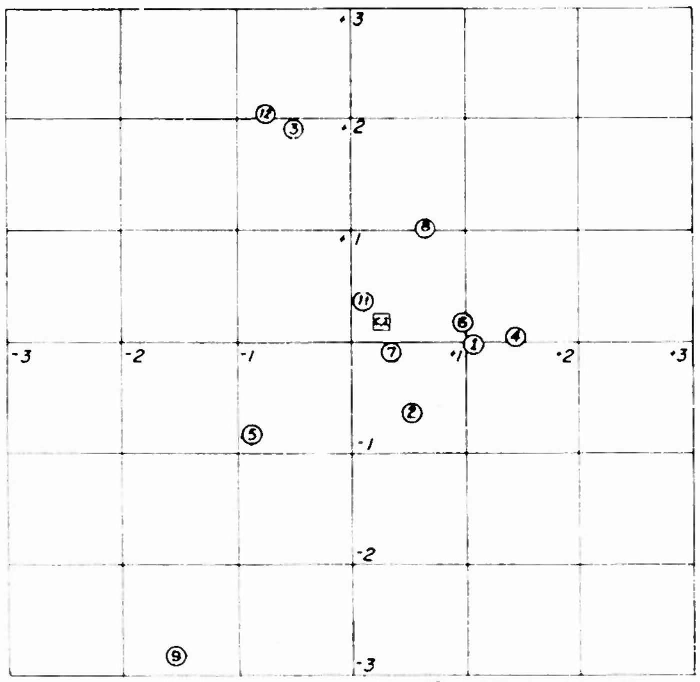


Fig. 14. T171MD10 Projectile.

feet per second, had a center of impact .11 mil above and .28 mil to the right of the aiming point. The round that missed the target appeared stable in flight but drifted to the right. The firing record for this program is shown in Table XII.

The large vertical dispersion may result either from the difficulty in maintaining a uniform loading density of the separately loaded rounds or from the low initial spin rate, or both. The large horizontal dispersion also suggests that the spin rate of 2 to 3 rps is not sufficient to yield satisfactory performance.



(Round 10 missed target)

Probable Error a/	
H.PE	= ±0.60
V.PE.	= ±0.90

Center of Impact a/	
H.C.I.	= +0.283
V.C.I	= +0.114

a/ mils

Fig. 15. Dispersion Chart
T171MD10 Projectiles.

Table XII
Range Data
T171MD8 and T171MD10 Projectiles

Gun —— 62.92' —— 1st. Velocity Coil & Yaw Card —— 105.83' —— 2nd. —— 37.57' —— 3rd. —— 55.92' —— 4th.

Screen Distances

Purpose of Test Accuracy of T171MD8 & MD10
Date of Test Aug 7, 1953

PROJECTILE

Model T-171
Type MD8 & MD10
Weight 17.50 lbs (Nom)
C.G. Location ——
Bourrelet Dia 4.132 -.002 in
Special Features MD8 (6 fin tail) / MD10 (T-section tail)

TEST GUN

Model T137E2
Type 105mm recoilless
Serial No ——
Chamber 1 K 679
Bushing (Vent) 6 8637
Tube 22-8-370-P, 1 in 20 twist
Sighting Equipment Gunners Quadrant, M1, #11324 & Elbow Telescope, M62E4, #18006
Mount Type T152E4 & concrete base

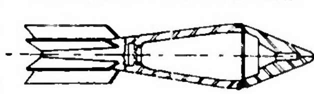
Solenoid Mechanical Firing System

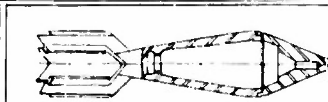
MISCELLANEOUS DATA

Range 998 yds. (d)
Propellant
Type M10MP Web .0335 in. Weight 8 lbs 8½ oz
Lot No PA30239
Primer T81
Shell Case T52
Liner T52 polyethylene
Temperatures
Magazine
Max 77°F Min 71°F Present 75°F
Loading Room —— Ambient 82°F

Round No (a)	Time of Flight	Proj Weight (lb.)	Proj. No (b)	Wind (c) Vel. mph	Wind (c) Dir degrees	Chamber Pressure (lb/sq in)	Muzzle Velocity ft/sec Instr	Muzzle Velocity ft/sec Actual	Azim (mils)	Elevation (mils) zero	Elevation (mils) super	Position of Hit (inches) Vert	Position of Hit (inches) Horiz	Corrected Position of Hit — mils Vert	Corrected Position of Hit — mils Horiz	Body Yaw (in.)	Observations
5514	—	1752	X 911	8	055	— 9800	1634	1669	0	5.4	23	—	—	—	—	—	Hit fourth coil.
5515	2.33333	17.50	X 905	7	058	9700 9400	1643	1692	0	5.4	23	- 10	+ 46	—	—	4¾ x 4⅛	Body yaw; hit 1¼ mil right, ¼ mil low
5516	—	17.51	X 902	10	045	9800 9400	1618	1653	0		23	—	—	—	—	—	Hit lost 3 coils, (sighting was correct)
5517	—	17.53	X 907	5	090	9400 9400	1652	1687	12		23	—	—	—	—	—	Low in front of target.
5518	—	17.52	X 912	9	060	9400 10100	1652	1687	12		23	—	—	—	—	—	Left and low.
5519	—	17.52	X 913	—	—	10300 9900	—	—	12		24	—	—	—	—	—	Over top the right
5520	—	17.51	X 903	7	058	10900 9400	—	—	12		23	—	—	—	—	—	Tumbled erratic to the left.
5521	2.22030	17.52	X 916	8	055	9900 10200	—	—	0		23	- ½	+ 37½	- .014	+1.044	4⅛ x 4⅛	Body yaw at target. Good flight.
5522	2.22896	17.54	X 923	9	075	7800 9500	1645	1674	0		23	- 22	+ 18½	- .612	+ .515	4⅛ x 4⅛	Very slight yaw Good flight.
5523	—	17.50	X 918	8	055	9400 7800	1647	1676	0		23	+ 69	- 18	+1.920	- .501	4⅛ x 4 3/16	Good flight
5524	—	17.53	X 922	11	063	9600 9500	1642	1671	0		23	+ 2½	+ 51	+ .070	+1.419	4⅛ x 4⅛	do.
5525	2.23445	17.52	X 921	9	100	9200 10200	1638	1667	0		23	- 29	+ 31½	- .807	+ .877	4⅛ x 4⅛	do.
5526	—	17.53	X 924	8	045	9600 10100	1650	1679	0		23	+ 6	+ 35½	+ .167	+ .988	4⅛ x 4⅛	do.
5527	—	17.53	X 919	9	060	10400 9300	1646	1675	0		23	- 3½	+ 11	- .097	+ .306	4⅛ x 4⅛	do.
5528	—	17.52	X 920	6	060	10300 9100	1661	1650	0		23	+ 37	+ 23½	+1.030	+ .654	—	do.
5529	—	17.52	X 914	7	048	10300 10400 7600	1651	1680	0		23	- 101	- 55½	-2.811	-1.545	4⅛ x 5⅜	Low & 2 mils left. Good flight. #4 hole plug came out.
5530	—	17.50	X 915	7	055	9700 10200	1649	1678	0		23	—	—	—	—	—	Missed target Good flight, 2 mils right
5531	2.22285	17.53	X 925	10	080	6800 9800	1646	1675	0		23	+ 13	+ 4½	+ .362	+ .125	4⅛ x 4⅛	Good flight
5532	2.25411	17.50	X 917	9	065	9200 8800	1627	1656	0		23	+ 73	- 27½	+2.032	- .765	4⅛ x 4⅛	do.

(a) Projectiles were placed in the tube so that the case would be at the rear of the projectile. This was done to give the same load density.
(b) Rounds 5514 to 5520 were MD8 type, rounds 5521 - 5532 were MD10 type.
(c) Clockwise from Magnetic North.
(d) Line of fire - 28° East of Magnetic North.


MD8


MD10

Center of Impact Vert +.113 mils, Horiz +.283 mils
Probable Error — Vertical ±.90 mils
Probable Error — Horizontal ±.60 mils
Rounds 5521 to 5532

Proof Director E. Hultman
Observers W.O. Davies, R. Barus, L. Swoebly
Signed O. Miller

Ballistic and Range Calculations

Using the Siacci theory and experimental data, ballistic coefficients for the T171MD3, MD5, MD10 and MD11 configurations were determined. From these ballistic coefficients the form factors and drag coefficients were computed. The terminal velocity, time of flight and elevation were found for various ranges and muzzle velocities, and the variations in vertical target strike which would result from errors in range estimation have been calculated.

Ballistic Coefficients

The Ballistic coefficients were found which satisfied the equations

$$C_T = \frac{t}{T_f - T_o}$$

$$C_S = \frac{x}{S_f - S_o}$$

where

- t = time of flight
- x = range
- T_o = Siacci time function at initial velocity.
- T_f = Siacci time function at final velocity.
- S_o = Siacci space function at initial velocity.
- S_f = Siacci space function at final velocity.
- C_T, C_S = Ballistic coefficients determined by time and space conditions.

The times of flight and muzzle velocities were measured, and the range was known. After the initial values of the space and time functions corresponding to the muzzle velocities were obtained from the tables, the terminal velocity was varied until the final values of the space and time functions were found that gave equal values of the ballistic coefficients, C_S and C_T.

This procedure was carried out with standard drag functions 1, 2, 7 and 8, and the standard function chosen was that one which best fit the experimental data. The best fit was assumed to be the function for which the standard deviation of the ballistic coefficients was a minimum.

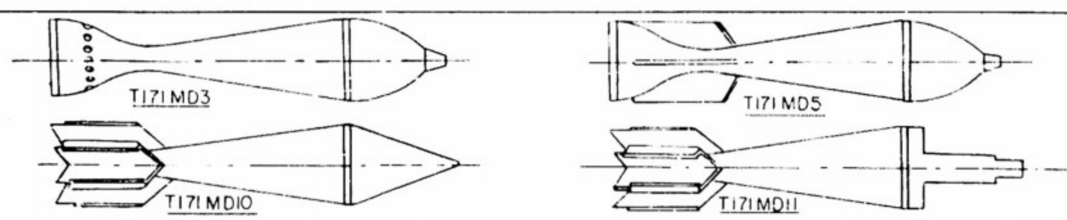
It was found that the number 2 standard function provides the best fit to the data for the MD11 projectile, and the number 7 standard function was chosen for the MD3, MD5, and MD10 modifications.

The form factors were then determined from the relation $i = \frac{m}{Cd^2}$

where
- i = form factor
- C = ballistic coefficient
- m = mass of shell
- d = diameter of shell

Values for the ballistic coefficient and the form factor are shown in Table XIII.

Table XIII
Ballistic Coefficients and Form Factors
T171MD3, MD5, MD10 and MD11 Projectiles



Projectile	Ballistic Coefficient	Form Factor	Standard Table
MD3	.3196	3.217	7.2
MD5	.3070	3.349	7.2
MD10	.5557	1.850	7.2
MD11	.5325	1.931	2.2

Drag Force Coefficients

With the aid of the expression

$$K_D = \frac{iG}{ku}$$

$k = 5.217 \times 10^{-4}$

i = form factor

G = drag function

u = velocity

the drag force coefficient - Mach number relationships for these four configurations were computed (Fig. 16). The solid sections of these curves are the portions of the curves to which the experimental data were applied, while the dotted lines are extrapolations of the standard curves using the above listed form factors. These results indicate that the drag force acting on each of these projectiles, using the MD10 modification as a base (=1.0), is 1.09 for the MD11, 1.74 for the MD3 and 1.81 for the MD5.

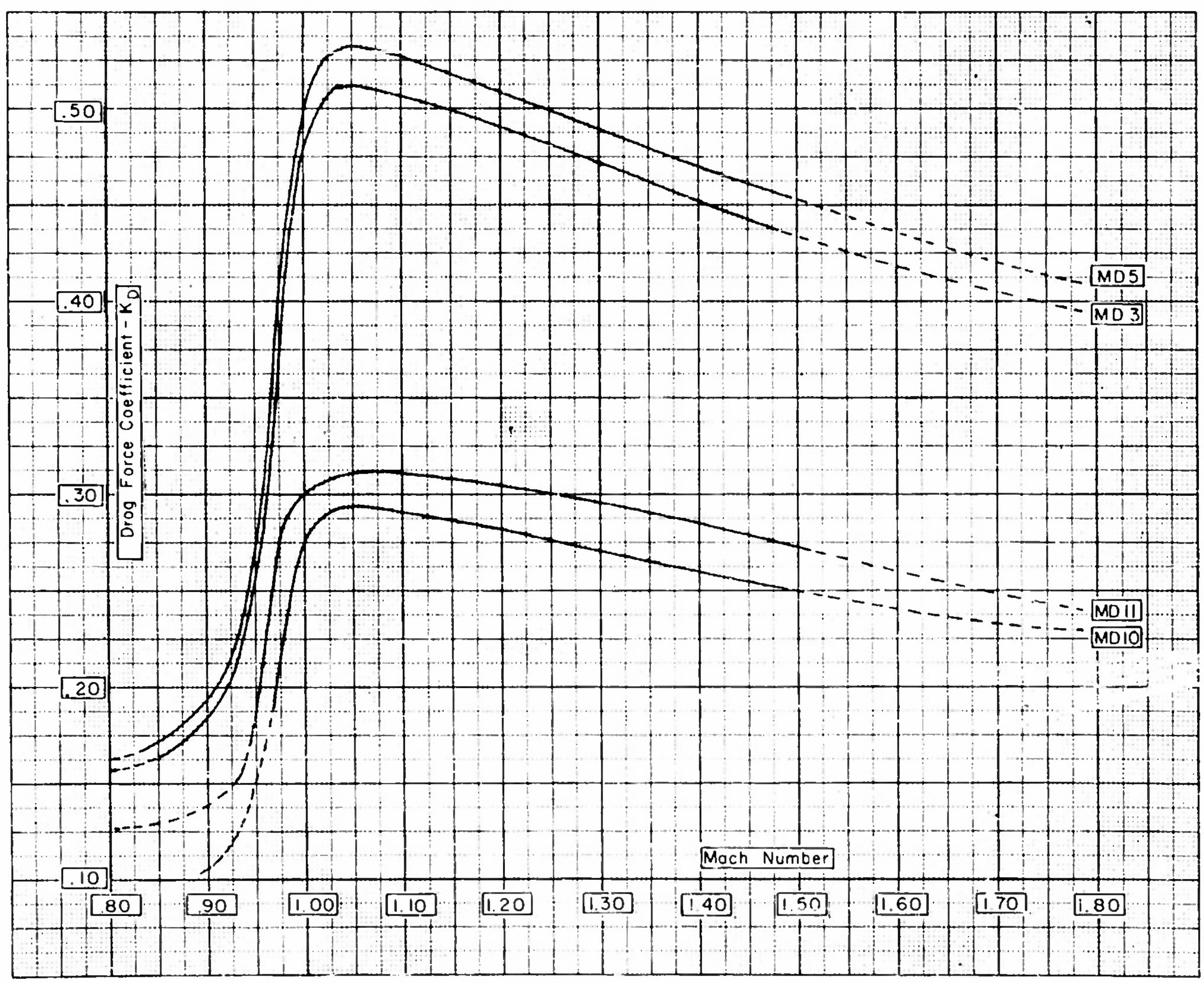


Fig. 16. Drag Force Coefficient Versus Mach Number.
T17, MD3, MD5, MD10 and MD11 Projectiles.

Trajectory Elements

The significance of a difference in drag force lies in its effect on the trajectory elements. Using the equations

$$S_f = S_o + \frac{x\sigma}{c} \sec\theta_o$$

$$y = x\tan\theta_o - \frac{c^2}{2\sigma^2}\left[(A_f - A_o) - I_o \frac{x\sigma}{c}\right]$$

$$t = \frac{c}{\sigma}\left[T_f - T_o\right]$$

$S_{o,f}$ = initial, final values of Siacci space function.

$T_{o,f}$ = initial, final values of Siacci space function.

$A_{o,f}$ = initial, final values of Siacci altitude functions.

I_o = initial value of Siacci inclination function.

x = range

c = ballistic coefficient

t = time of flight

y = elevation

σ = ratio of density of air to standard density.

the elevations, terminal velocities, and times of flight were related to varying muzzle velocity for ranges of 1000 yards and 2000 yards, (Figures 17-22), and to range for a muzzle velocity of 1650 feet per second (Figures 23-25).

It is easily seen that the MD10 and MD11 modifications are superior to the MD3 and MD5 modifications when drag force alone is considered. The required elevation for the MD10 is 3% less than that for the MD11 at 1000 yards, and 5% less at 2000 yards. The remaining velocities of the MD10 at 1000 yards and 2000 yards are, respectively, 3% and 6% higher than those of the MD11 at the same ranges, while the times of flight for the MD10 at 1000 yards and 2000 yards are 2% and 3% lower than those of the MD11 at those ranges.

Variation in Hit

The variations in vertical target hit as a function of range error, for ranges of 1000 yards and 2000 yards, and as a function of range, for a 15% range error, were determined using the equation

$$y = x\tan\theta - \frac{c^2}{2\sigma^2}\left[(A - A_o) - \frac{I_o x\sigma}{c}\right]$$

and plotted in Figs. 26, 27 and 28. These graphs also show the superiority of the MD10 and MD11 modifications over the MD 3 and MD5 rounds. It is apparent that the MD10 is an improvement over the MD11, especially for extended ranges, when this variation is considered.

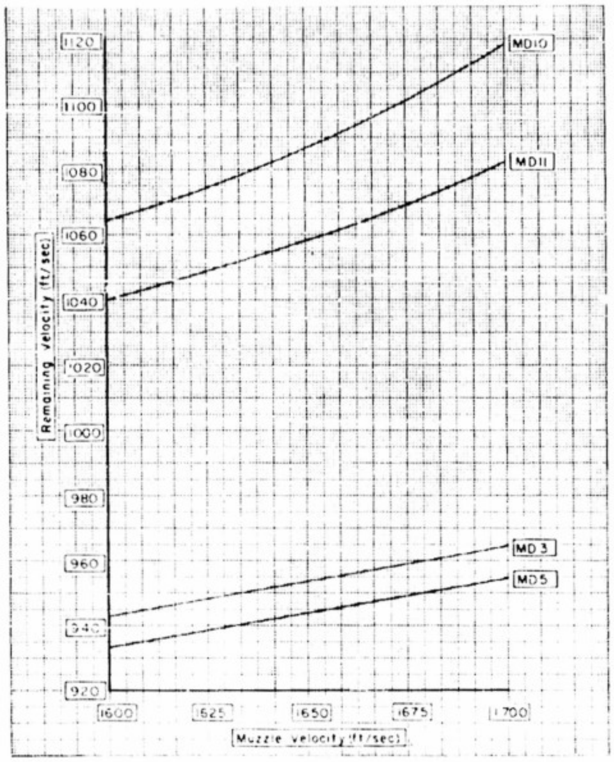


Fig. 17. Remaining Velocity Versus Muzzle Velocity.
T171MD3, MD5, MD10 and MD11 Projectiles; 1,000-yard Range.

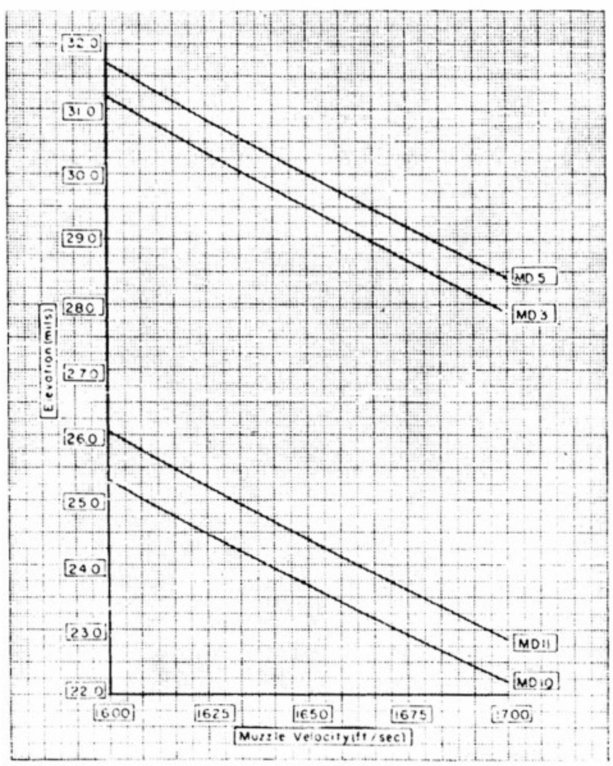


Fig. 18. Elevation Versus Muzzle Velocity.
T171MD3, MD5, MD10 and MD11 Projectiles; 1,000-yard Range.

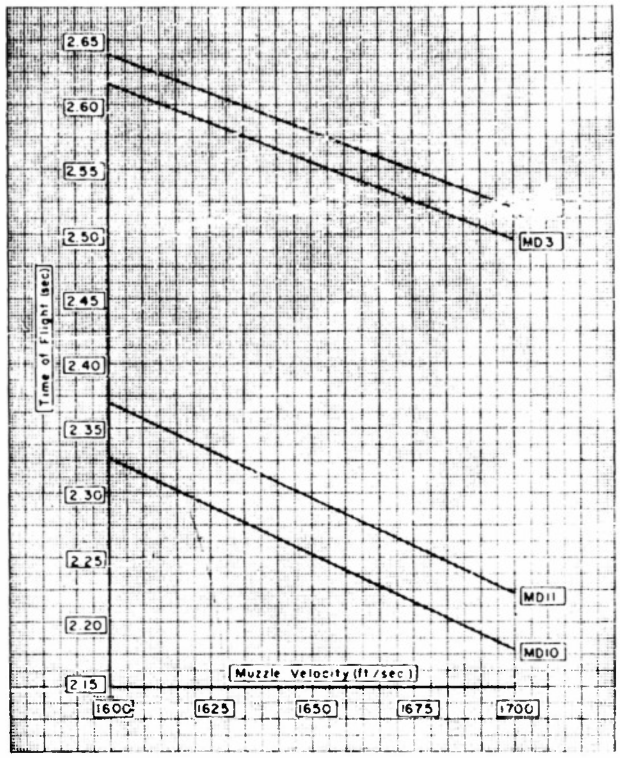


Fig. 19. Time of Flight Versus Muzzle Velocity.
T171MD3, MD5, MD10 and MD11 Projectiles; 1,000-yard Range.

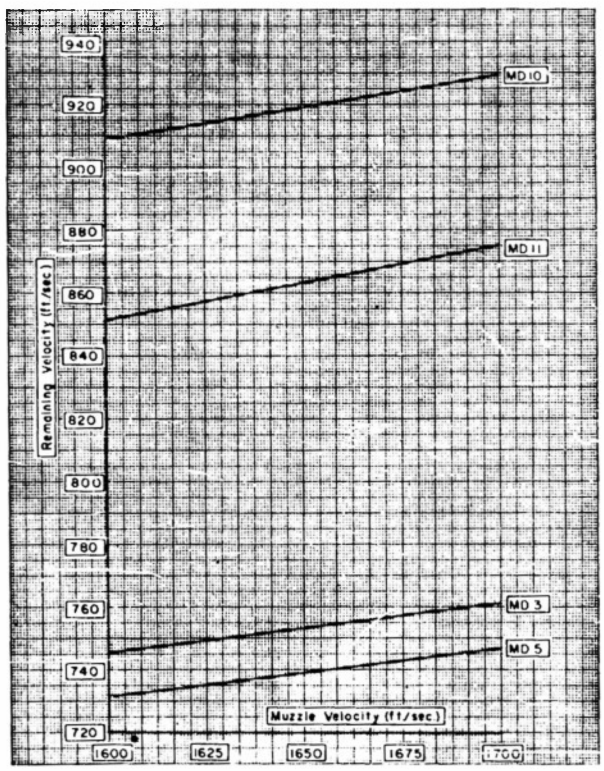


Fig. 20. Remaining Velocity Versus Muzzle Velocity.
T171MD3, MD5, MD10 and MD11 Projectiles; 2,000-yard Range.

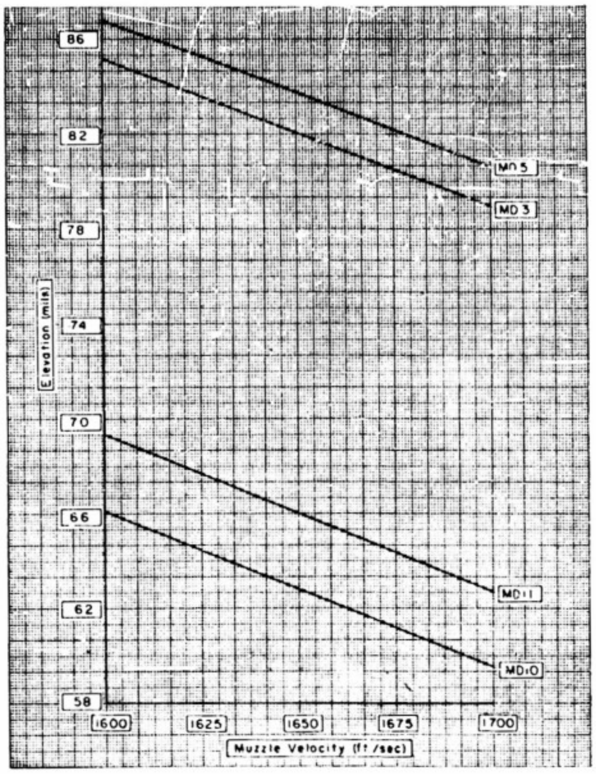


Fig. 21. Elevation Versus Muzzle Velocity.
T171MD3, MD5, MD10 and MD11 Projectiles; 2,000-yard Range.

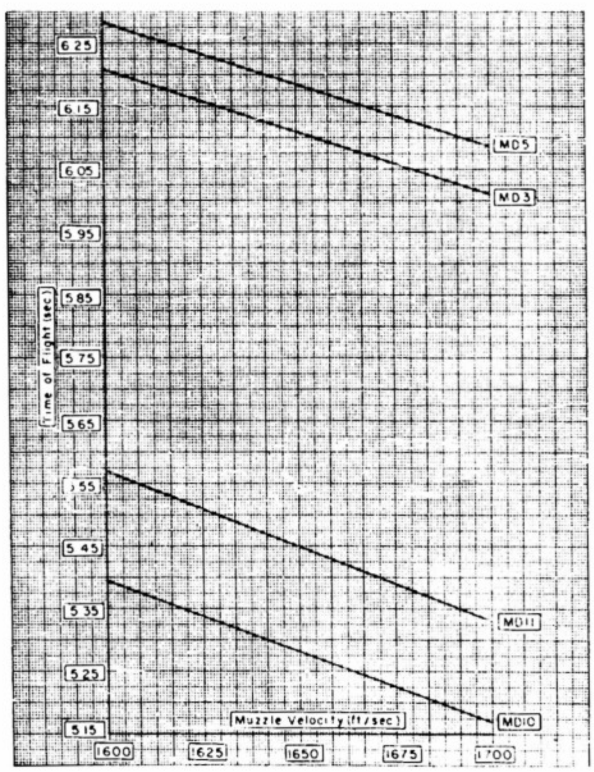


Fig. 22. Time of Flight Versus Muzzle Velocity.
T171MD3, MD5, MD10 and MD11 Projectiles; 2,000-yard Range.

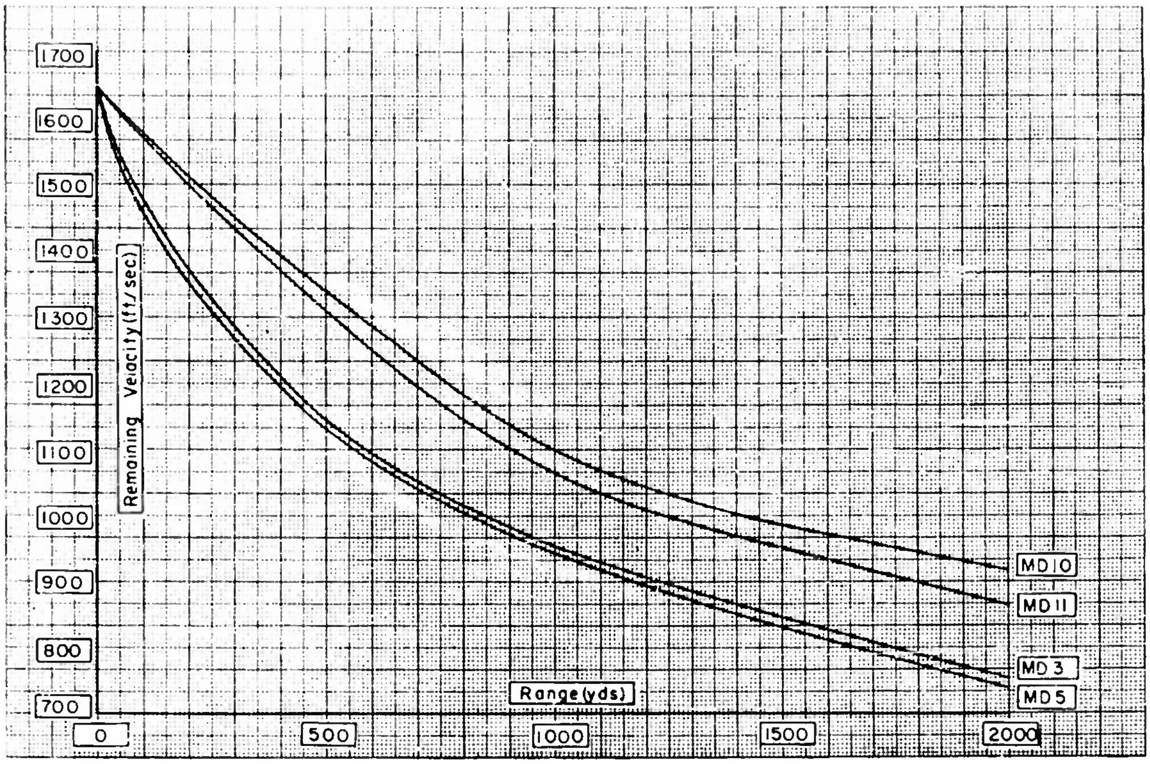


Fig. 23. Remaining Velocity Versus Range.
T171MD3, MD5, MD10 and MD11 Projectiles.

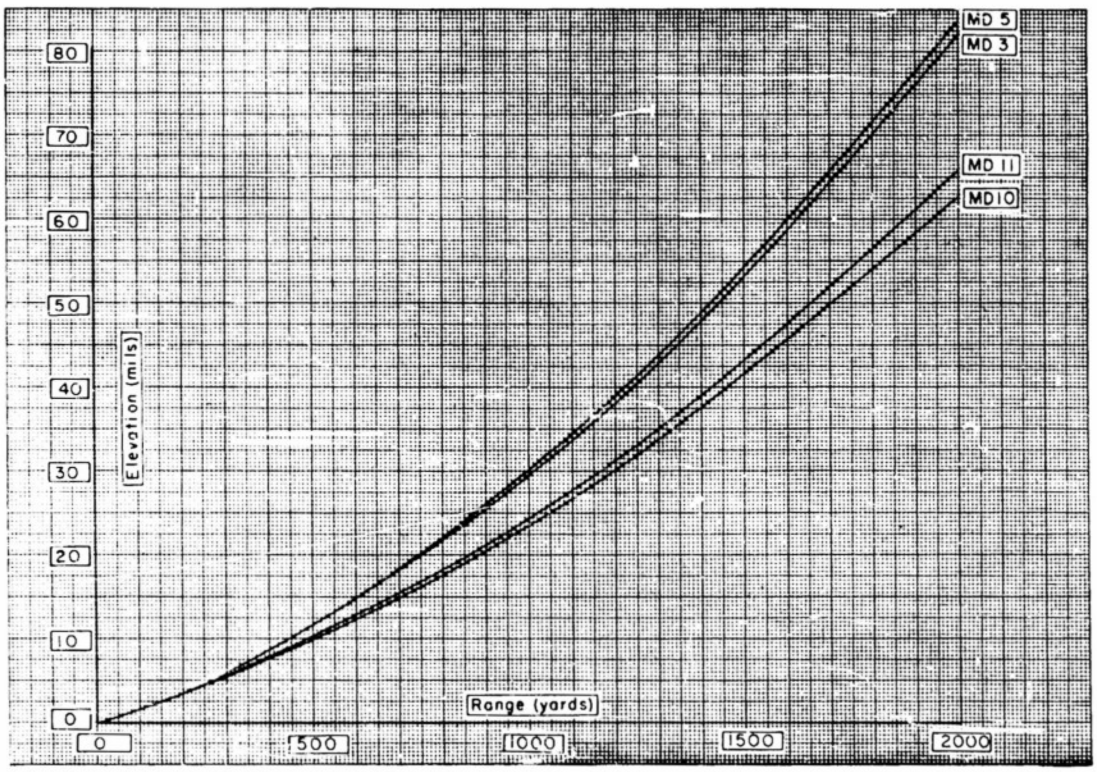


Fig. 24. Elevation Versus Range.
T171MD3, MD5, MD10 and MD11 Projectiles.

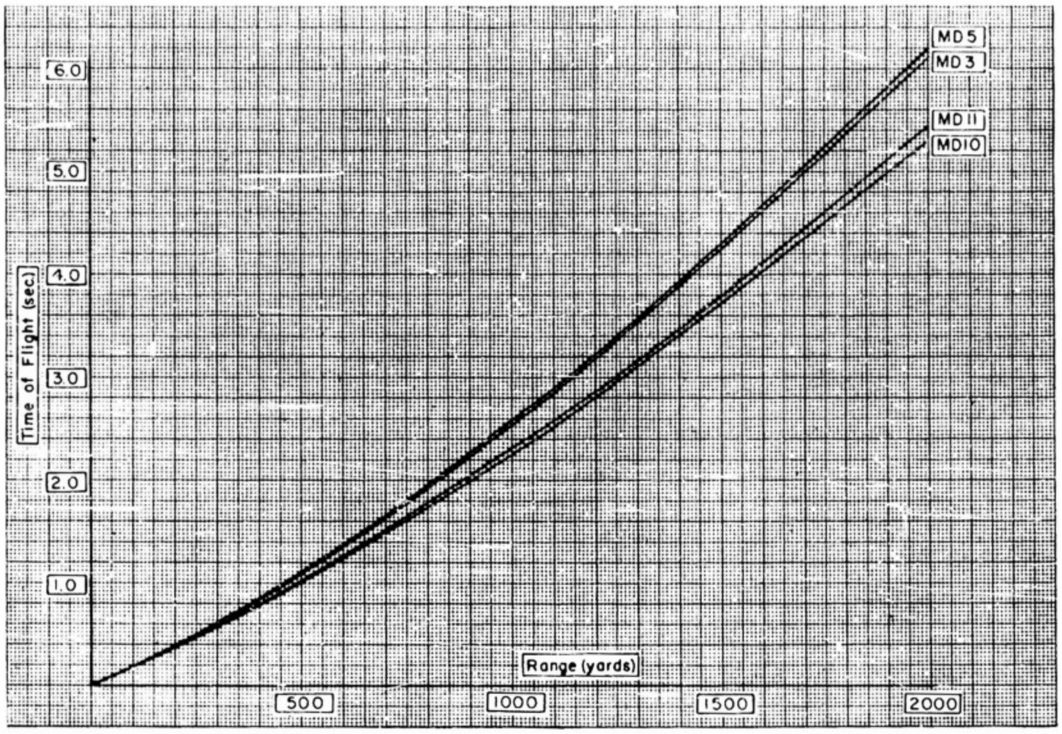


Fig. 25. Time of Flight Versus Range.
T171MD3, MD5, MD10 and MD11 Projectiles.

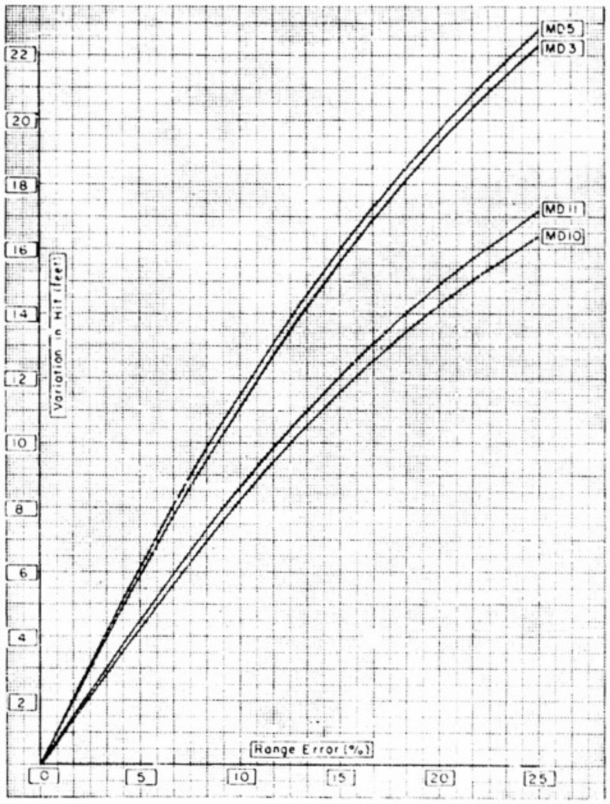


Fig. 26. Variation in Hit Versus Range Error.
T171MD3, MD5, MD10 and MD11 Projectiles, 1,000-yard Range.

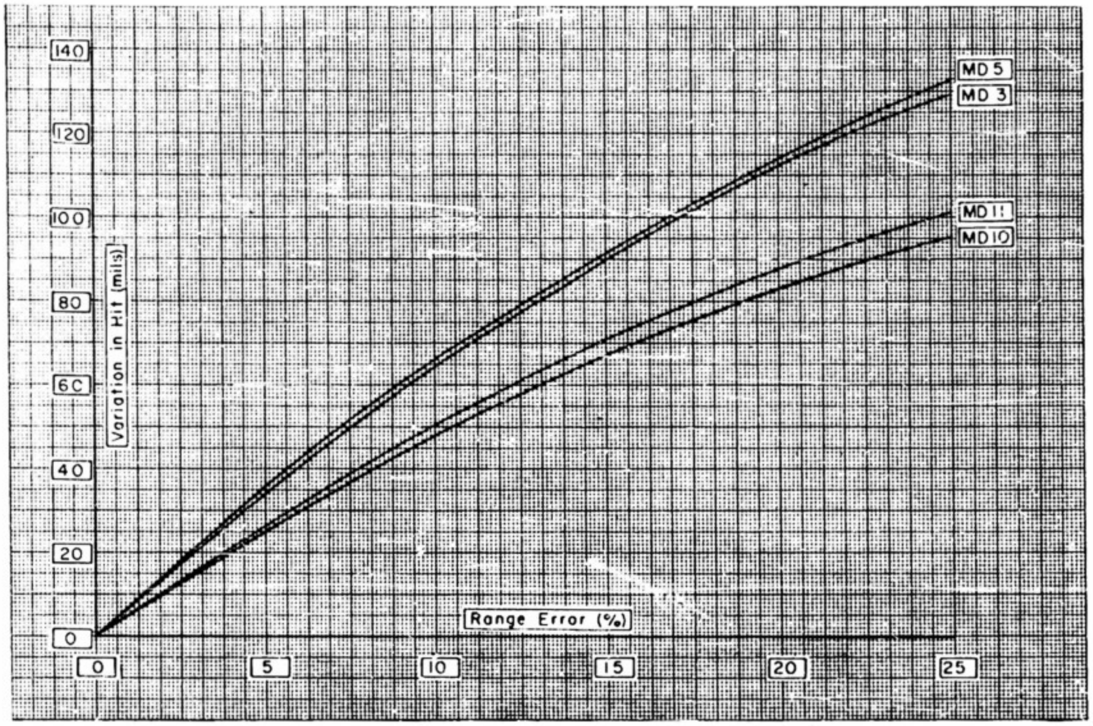


Fig. 27. Variation in Hit Versus Range Error.
T171MD3, MD5, MD10 and MD11 Projectiles; 2,000-yard Range.

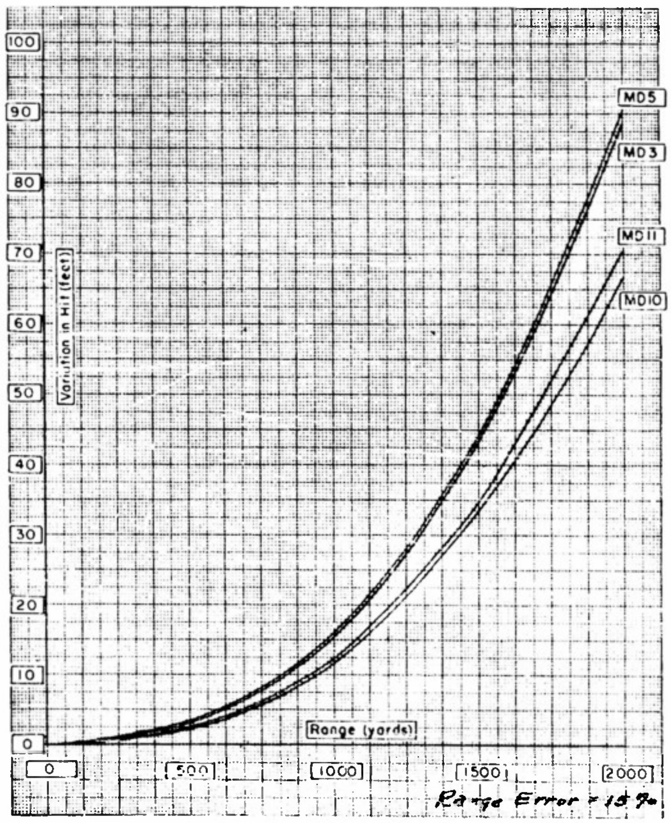


Fig. 28. Variation in Hit Versus Range.
T171MD3, MD5, MD10 and MD11 Projectiles.

Future Program

1. Because of the advantage the reduced drag force provides and the simplification of penetration problems offered by the conical nose, continued emphasis will be placed on achieving satisfactory accuracy with the MD10 modification. Several T171MD10 projectiles are at Erie Ordnance Depot awaiting firing from a 1-500 twist tube. This test is designed to show the effect of spin rate upon the accuracy of this projectile.

2. A test similar to (1) is planned for T171 MD11 projectiles.

3. T171 MD11 projectiles, modified by replacing the regular tee with the T138 E23M nose (page 19, BRL Memo Report 592, A. S. Platou) are being prepared for evaluation tests.

Scaling Studies

Two separate but related scaling studies have now been completed. One is based upon the DRB398 copper cone and the first part of this study (75mm) was presented in the Thirty-Fifth Progress Report. The second considered a family of 45° sharp apex copper cones and was reported in the Thirty-Sixth Progress Report. In this report new data for the 90mm size DRB398 type cone is presented and all data for the two studies are summarized.

The 90/105mm scaled counterpart of the DRB398 cone and DRC376 test assembly consists of a DRB707 cone and DRC506-1 test assembly (No. 2 nose ring). Fig. 29 shows the cone and Fig. 30 shows a cone and charge assembly. These cones were made from DRB398 drawn cones by cutting them off at the appropriate base diameter (3.0 inch register diameter) and by machining the inside wall surface to the specified wall thickness (.086 inch). The only departure from linear scaling is in the small spitback tube whose dimensions are unchanged from the original DRB398 cone.

The inspection data for the DRB707 cones are shown in Table XIV and the penetration data are shown in Tables XV(A) and XV(B).

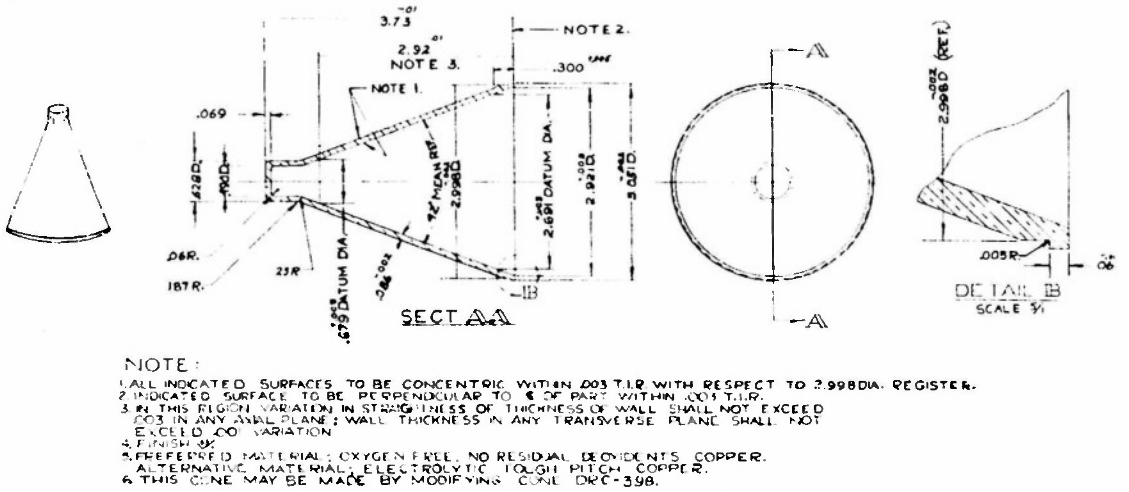


Fig. 29. DRB707 90 mm. Smooth Cone.
90/105 Scaled Counterpart of DRB398 Cone.

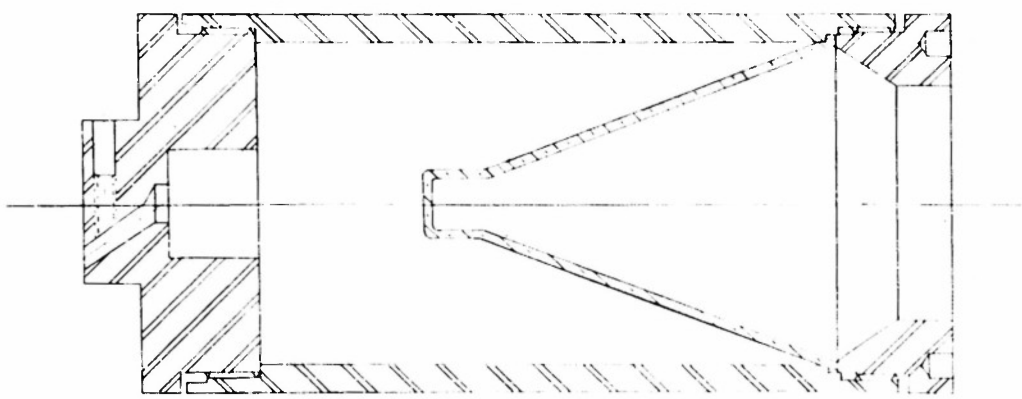


Fig. 30. DRC506-1 90 mm. Penetration Test Assembly.
90/105 Scaled Counterpart of DRC376 Assembly.

Table XIV
Inspection Data
DRB707 Cones

Cone No.	Wall Thickness (inches)			Max Variation in Wall Thickness(in.)		Max. Wall Waviness-in.		Concentricity T.I.R. (in.)[2]		
	Max.	Min.	Avg.	Transverse	Longitud.	O. D.	I. D.	Base[1] Datum	Apex Datum	Cone Tip in Assembly
Specification DRB707 Cone	.086	.084	--	.001	.003	.003	.003	.0030	.0030	.015 (Maximum)
FS1049	.086	.085	.0851	.001	.001	.002	.002	.0010	.0020	.005
FS1050	.088	.086	.0865	.002	.002	.001	.002	.0020	.0025	.010
FS1051	.085	.084	.0845	.001	.001	.001	.002	.0040	.0010	.004
FS1052	.090	.085	.0878	.001	.004	.002	.005	.0020	.0015	.002
FS1053	.092	.086	.0890	.001	.005	.002	.003	.0020	.0010	.004
FS1054	.090	.085	.0875	.001	.004	.002	.003	.0020	.0020	.010
FS1055	.094	.086	.0898	.001	.008	.002	.008	.0015	.0040	.008
FS1056	.086	.084	.0851	.001	.002	.002	.003	.0010	.0020	.005
FS1057	.085	.085	.0850	<.001	<.001	.002	.002	.0020	.0020	.008
FS1058	.086	.084	.0851	.001	.002	.002	.003	.0010	.0020	.010
FS1059	.086	.084	.0850	.001	.002	.002	.003	.0020	.0020	.007
FS1060	.087	.086	.0865	.003	.003	.002	.002	.0015	.0040	.006
FS1061	.085	.084	.0845	.002	.002	.002	.002	.0030	.0060	.016
FS1062	.090	.086	.0880	<.001	.004	.002	.004	.0020	.0010	.004
FS1063[3]	---	---	---	NO DATA		---	---	---	---	---
FS1064	.087	.085	.0863	.002	.001	.002	.002	.0020	.0040	.005
FS1065	.087	.085	.0860	.001	.001	.003	.002	.0020	.0040	.012
FS1066	.090	.086	.0879	.003	.003	.002	.003	.0020	.0030	.006
FS1067	.086	.084	.0853	.001	.002	.002	.003	.0010	.0010	.008
FS1068	.088	.085	.0864	.001	.003	.002	.005	.0020	.0010	.005
FS1069	.085	.082	.0843	.002	.003	.002	.004	.0020	.0020	.001
FS1070	.087	.085	.0860	.002	.002	.002	.004	.0020	.0010	.017
FS1071	.087	.084	.0854	.001	.003	.002	.004	.0010	.0010	.002
FS1072	.085	.083	.0840	.001	.002	.002	.003	.0020	.0010	.010
FS1073	.090	.085	.0875	.002	.005	.002	.005	.0020	.0010	.006
FS1074	.086	.085	.0853	.001	.001	.002	.004	.0030	.0010	.010
Avg.	.0875	.0848	.0862	.0013	.0026	.0020	.0033	.0019	.0021	.0072
Std. Dev.	±.0024	+.0010	±.0017	±.0007	±.0017	±.0004	±.0014	±.0007	±.0013	±.0039

Notes:

1. Lower datum is .484 inch above base; the upper datum is 2.92 inches above base.
2. The indicated measurement at each datum is the total indicator runout of the liner's outside surface relative to the register diameter. The difference between the runout at the two datum planes is an indication of the lack of perpendicularity of the register plane and the liner axis.
3. Held as sample.

Table XV
Penetration Data
DRB707 Cones

Round No.	Lb. Comp B	Standoff (in.)	Penetration (inches M.S.)	Max. Spread (in.)	Std. Deviation (in.)
A. Effect of Standoff					
FS1049	1.56	6.0	18.69		
FS1050	1.58	6.0	16.94		
FS1051	1.60	6.0	15.81		
FS1052	1.58	6.0	17.31		
			Avg. 17.19	2.88	±1.19
FS1053	1.56	9.0	18.31		
FS1054	1.56	9.0	18.25		
FS1055	1.58	9.0	17.94		
FS1056	1.60	9.0	17.44		
			Avg. 17.99	.87	±0.40
FS1057	1.58	12.0	19.12		
FS1058	1.56	12.0	17.44		
FS1059	1.58	12.0	18.62		
FS1060	1.58	12.0	19.12		
			Avg. 18.58	1.68	±0.80

Notes:
1. Cones were modified from drawn DRB398 HW3 item 1 copper cones, and were assembled in DRC506-1 test bodies, plugs and No. 2 nose rings.
2. Loaded at Ravenna Arsenal, BAT Lot No. 32, with Composition B from Holston Lot No. 4-1197.
3. Tested at Erie Ordnance Depot without rotation;mild steel target plate was used.

B. Effect of Rotation

Round No.	Lb. Comp B	Rev/Sec	Penetration Inches M.S.	Max. Spread (in.)	Std. Deviation (in.)
FS1049	1.56	0	18.69		
FS1050	1.58	0	16.94		
FS1051	1.60	0	15.81		
FS1052	1.58	0	17.31		
			Avg. 17.19	2.88	±1.19
FS1061	1.56	30	15.25		
FS1062	1.58	30	14.75		
FS1074	1.58	30	13.88		
FS1064	1.60	30	12.75		
			Avg. 14.16	2.50	±1.10
FS1065	1.56	60	8.18		
FS1066	1.56	60	7.75		
FS1067	1.56	60	8.18		
			Avg. 8.04	0.43	±.25
FS1068	1.58	90	6.56		
FS1069	1.56	90	6.62		
FS1070	1.58	90	6.50		
			Avg. 6.56	0.12	±.06
FS1071	1.58	120	5.94		
FS1072	1.56	120	5.56		
FS1073	1.58	120	5.38		
			Avg. 5.63	0.56	±.29

Notes:
1. Cones were modified from drawn DRB398 HW3 item 1 copper cones, and were assembled in DRC506-1 test bodies, plugs and No. 2 nose rings.
2. Loaded at Ravenna Arsenal, BAT Lot No. 32, with Composition B from Holston Lot No. 4-1197.
3. Tested at Erie Ordnance Depot at a standoff of 6.0 inches. Mild steel target plate was used.

Scaling of Standoff

The penetration data for the effect of standoff are shown in Fig. 31 and are compared directly with similar data for the 75mm and 105mm scaled counterparts. The curves have the same general shape. Fig. 32 is a generalized plot showing the effect of standoff. Data for both scaling studies are included in this curve. Both depth of penetration and standoff distance are expressed in terms of charge diameters. In confirmation of generally accepted theory a single curve represents the data adequately for standoff distances up to 4 or 5 charge diameters. At longer standoff distances other factors such as precision of manufacture, charge symmetry, etc., become increasingly important.

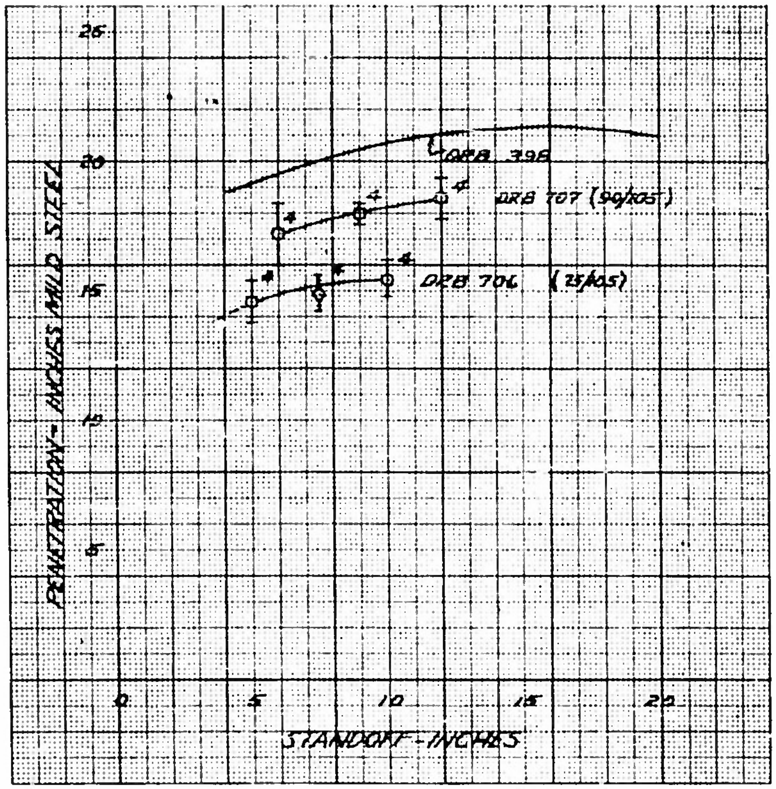


Fig. 31. Penetration Versus Standoff.
75 mm., 90 mm. and 105 mm. Cones Type Cones.

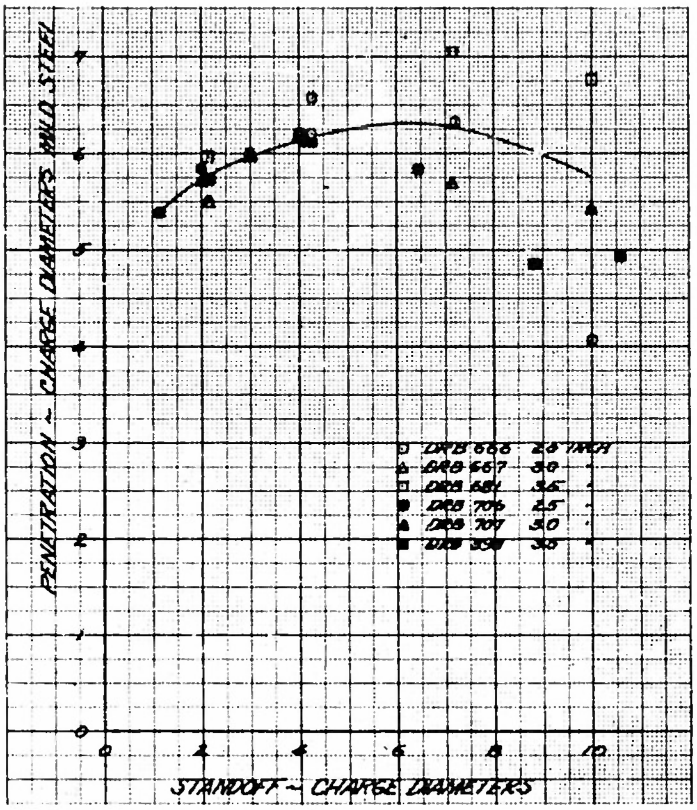


Fig. 32. Penetration Versus Standoff.
In Terms of Charge Diameters.

Scaling of the Rotational Effect

The penetration vs spin rate curve for the 90/105 modification of the DRB 398 type cone is shown in Fig. 33, Fig. 34 is a generalized plot in which the data for both sharp apex and spitback tube types of cones are presented. The data for a 1.63 inch diameter charge (Carnegie Institute of Technology, Report No. CIT-ORD-R18), though not scaled directly, are also shown for comparison. The penetration ($P\omega$) at any spin rate (ω radians/sec) is expressed as a fraction of the non rotated penetration (P_o) and is equal to $\frac{P_\omega}{P_o}$. The spin rate is expressed in terms of surface speed and is equal to ωr. As expected the effect of spin is invariant under these transformations and the one curve represents the data for all of the charges quite well. There are, however, certain restrictions upon the general applicability of the relationship between spin rate and penetration shown in Fig. 34. The data were obtained using conical copper cones of such quality that without rotation they would penetrate approximately 6.0 charge diameters into mild steel target. Charges of poorer quality, or of other shapes or materials will lose their penetration at a different rate. Under these latter conditions the empirical relationship presented in the Supplement to the Penetration Studies beginning on page 38 of the Eleventh Progress Report is more nearly applicable.

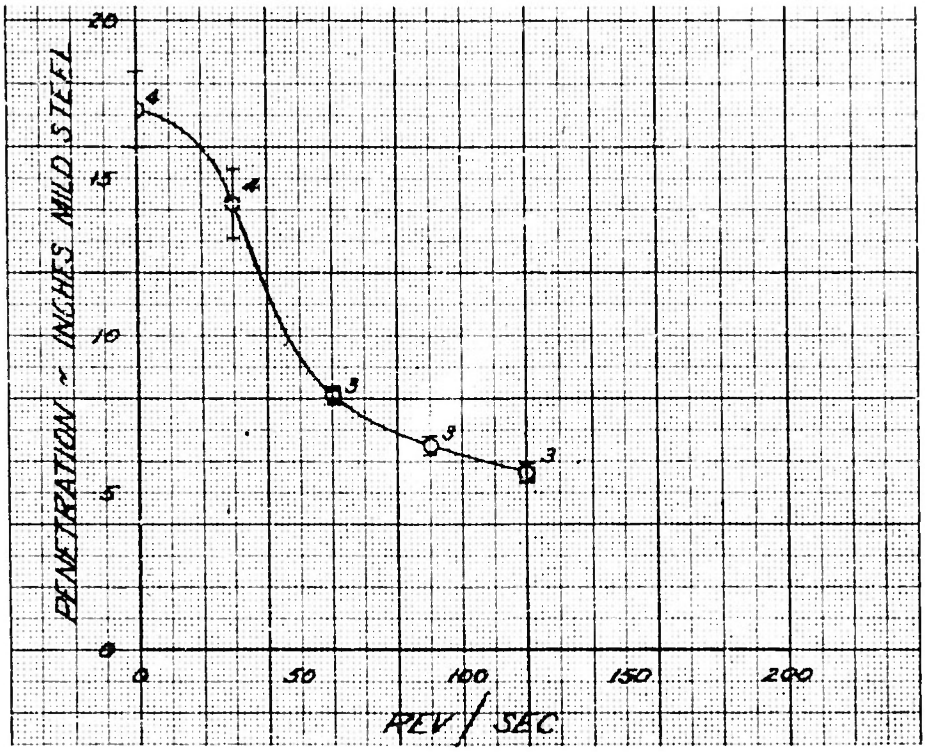


Fig. 33. Penetration Versus Rotation.
90/105 Scaled Counterpart of DRB398 Cone.

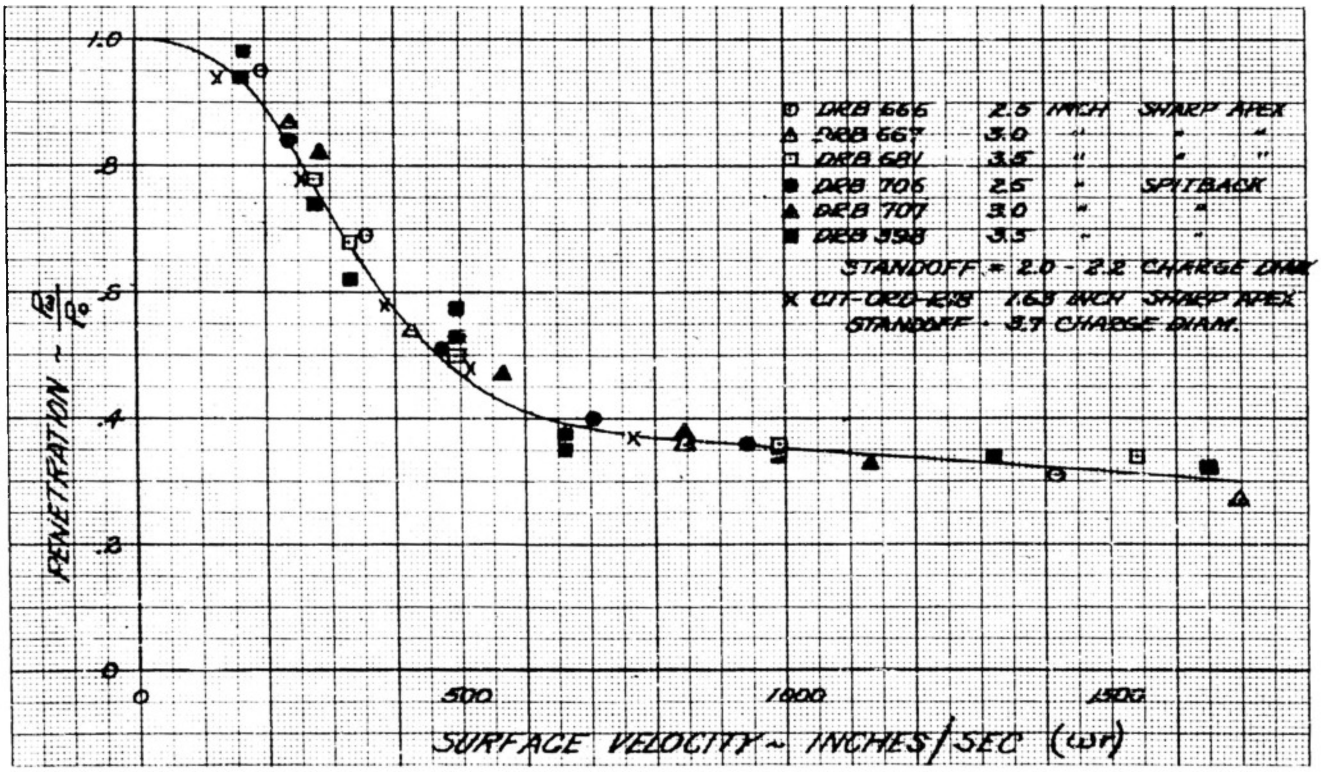
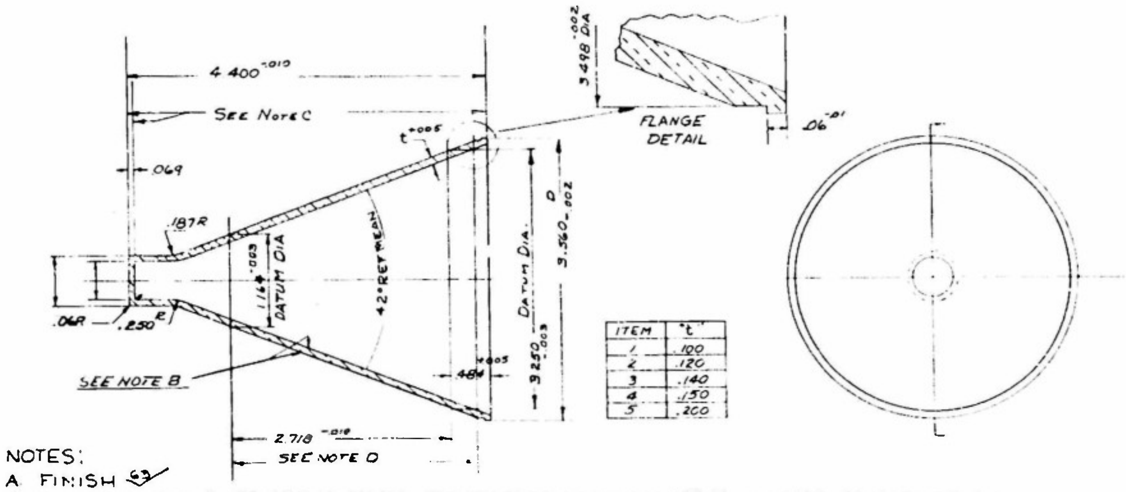


Fig. 34. Penetration Versus Surface Velocity.
2.5-in., 3.0-in., and 3.5-in. Sharp Apex and Spitback Cones.

Penetration of DRB398 Cones At High Spin Rates

The penetration spin rate behavior of DRB398 copper cones has been well established between the spin rates of -25 rps and +30 rps. These data have been presented in Fig. 6 of the Twenty-Seventh Progress Report. The tests have been continued and data are now available for spin rates up to 250 rps. In this experiment the bases of the cones were modified to provide a small clamping flange. Fig. 35 shows the cone (DRB398HW3 item 1) and Fig. 36 shows a DRC376 test assembly with No. 2 nose ring. The inspection data for these cones are shown in Table XVI and the penetration data are presented in Table XVII and Fig. 37. The dotted curve shown in Fig. 37 is for the earlier data. (Fig. 6 of the Twenty-Seventh Progress Report). The agreement is excellent.



NOTES:
A. FINISH
B. ALL INDICATED SURFACES MUST BE CONCENTRIC WITHIN .003 T.I.R. WITH RESPECT TO 3.560 DIA.
C. ALL INDICATED SURFACES MUST BE FLAT & PARALLEL WITHIN .005 T.I.R. & PERPENDICULAR TO ℄ OF PART.
D. IN THIS REGION VARIATION IN STRAIGHTNESS OR THICKNESS OF WALL SHALL NOT EXCEED .006 IN ANY AXIAL PLANE. VARIATION OF WALL THICKNESS IN ANY TRANSVERSE PLANE SHALL NOT EXCEED .002.
E. PREFERRED MATERIAL: OXYGEN FREE, NO RESIDUAL DEOXIDANTS, COPPER.

Fig. 35. DRB398 HW3 Item 1 Cone.

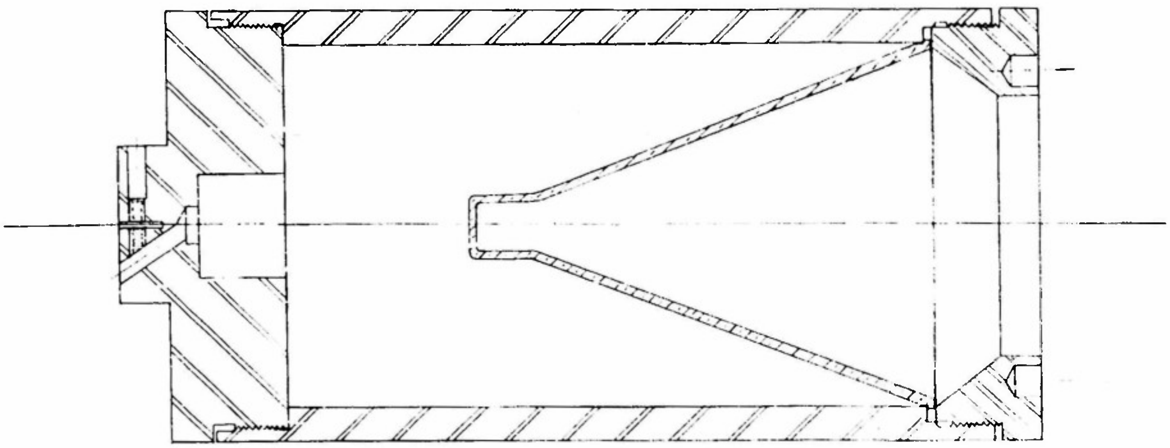


Fig. 36. DRC376 Penetration Test Assembly.
DRB398 Cone.

Table XVI
Inspection Data
DRB398 HW3 Item 1 Cones

Cone No.	Wall Thickness (inches)			Max. Wall Thickness Variation (in.)		Max. Wall Waviness (in.)		Concentricity T. I. R. [1,2]		
	Max.	Min.	Avg.	Transverse	Longitud.	O. D.	I. D.	Base Datum	Apex Datum	Cone Tip in Assembly
Specification DRB398 HW3 Item I Cones	.105	.100	---	.002	.006	.003	.003	.0030	.0030	.015 (Nominal)
R56	.103	.100	.1016	.002	.003	.002	.003	.002	.0010	.002
R57	.105	.102	.1040	.003	.003	.003	.004	.002	.0020	.003
R58	.104	.102	.1024	.002	.002	.003	.003	.002	.0020	.002
R59	.104	.101	.1021	.002	.002	.003	.002	.003	.0020	.003
R60	.103	.101	.1020	.002	.002	.002	.002	.002	.0010	.003
R61	.100	.096	.0988	.002	.004	.004	.004	.002	.0010	.004
R62	.103	.100	.1013	.002	.002	.003	.002	.002	.0020	.006
R63	.101	.099	.0999	.001	.002	.003	.002	.004	.0030	.002
R64	.103	.100	.1018	.002	.002	.002	.002	.004	.0040	.003
R65	.102	.100	.1014	.001	.001	.001	.003	.002	.0010	.002
R66	.102	.100	.1011	.002	.002	.002	.003	.003	.0020	.002
R67	.101	.098	.1000	.003	.002	.003	.003	.002	.0020	.003
R68	.104	.102	.1029	.002	.002	.002	.002	.002	.0030	.005
R69	.103	.100	.1014	.003	.001	.002	.001	.002	.0030	.010
R70	.104	.101	.1024	.003	.002	.002	.002	.001	.0020	.009
R71	.104	.102	.1029	.002	.002	.002	.002	.002	.0020	.002
R72	.102	.098	.1003	.004	.003	.002	.003	.002	.0020	.006
R73	.103	.101	.1016	.002	.002	.002	.002	.002	<.0010	.002
R74	.102	.100	.1009	.002	.002	.002	.002	.002	.0010	.006
R75	.104	.100	.1023	.004	.002	.003	.002	.001	.0020	.002
R76	.103	.101	.1019	.002	.002	.003	.002	.002	.0020	.007
R77	.107	.101	.1034	.005	.004	.002	.004	.003	.0040	.002
R78	.105	.102	.1034	.002	.002	.002	.002	.002	.0010	.003
R79	.103	.102	.1026	.001	.001	.002	.005	.002	.0020	.004
R80	.105	.102	.1036	.003	.002	.002	.003	.002	.0020	.006
R81	.105	.103	.1041	.002	.002	.002	.002	.001	.0020	.002
R82	.105	.102	.1038	.003	.002	.002	.002	.002	.0020	.004
R83	.102	.098	.1000	.004	.002	.003	.002	.002	.0010	.001
R84	.101	.100	.1006	.001	.001	.002	.002	.002	.0020	.008
R85	.101	.100	.1005	.001	.001	.002	.003	.003	.0030	.005
Avg.	.1031	.1005	.1018	.0023	.0021	.0023	.0025	.0022	.0020	.0040
Std. Dev.	±.0015	±.0016	±.0013	±.0010	±.0007	±.0006	±.0009	±.0007	±.0012	±.0023

Notes:
1. Lower datum is .484 inch above base; upper datum is 3.302 inches above base.
2. The indicated measurement at each datum is the total indicator runout of the liner's outside surface relative to the register diameter. The difference between the runout at the two datum planes is an indication of the lack of perpendicularity of the register plane and the liner's axis.

Table XVII
Penetration Data
DRB398 HW3 Item 1 Cones

Round No.	Lb. CompB	RPS	Penetration (inches M.S.)	Max. Spread (in.)	Std Deviation (in.)
R56	2.50	0	19.18		
R57	2.46	"	19.18		
R58	2.46	"	22.69		
			Avg. 20.35	3.51	±2.03
R59	2.46	15	19.81		
R60	2.46	"	20.25		
R61	2.46	"	20.06		
			Avg. 20.04	0.44	±0.22
R62	2.46	30	13.88		
R63	2.46	"	13.75		
R64	2.46	"	14.06		
			Avg. 13.90	0.31	±0.16
R65	2.46	45	9.69		
R66	2.46	"	9.88		
R67	2.46	"	9.44		
			Avg. 9.67	0.44	±0.22
R68	2.46	60	7.75		
R69	2.46	"	7.75		
R70	2.46	"	7.44		
			Avg. 7.65	0.31	±0.18
R71	2.46	90	6.56		
R72	2.46	"	7.25		
R73	2.48	"	7.00		
			Avg. 6.94	0.69	±0.35
R74	2.46	120	5.81		
R75	2.44	"	7.18		
R76	2.44	"	7.88		
			Avg. 6.96	2.07	±0.85
R77	2.46	150	7.06		
R78	2.44	"	6.94		
R79	2.46	"	5.81		
			Avg. 6.60	1.25	±0.69
R80	2.44	180	4.81		
R81	2.46	"	4.56		
R82	2.46	"	4.31		
			Avg. 4.56	0.50	±0.25
R83	2.48	250	4.69		
R84	2.46	"	4.94		
R85	2.44	"	4.38		
			Avg. 4.67	0.56	±0.28

Notes:
1. Cones were drawn DRB398 HW3 item 1 copper cones assembled in DRC376 test bodies, plugs and No. 2 nose rings.
2. Loaded at Ravenna Arsenal, BAT Lot No. 34, with Composition B from Holston Lot No. 4-1197.
3. Tested at Erie Ordnance Depot, mild steel target plate, 7.5 inch standoff.

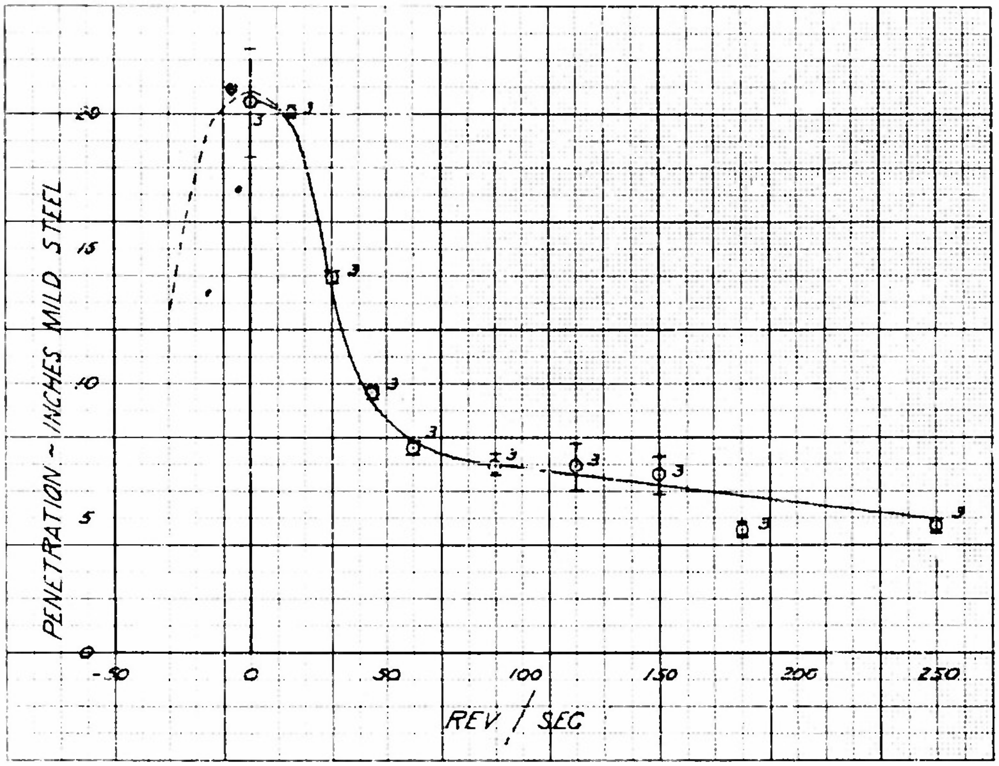


Fig. 37. Penetration Versus Rotation.
At High Spin Rates.

Behavior of Zinc Alloys (Zamak 3)

At the Quarterly Meeting of the Shaped Charge Committee held January 28, 1953, in the Ballistic Research Laboratory at Aberdeen Proving Ground, Mr. Guy Throner (Naval Ordnance Test Station , China Lake, Inyokern, California) reported 26 cast Zamak 5 cones having an apex angle of 42.5° and a 4% wall thickness penetrated 6.2 cone diameters into mild steel target. This level of performance is as good as is normally obtained with well made copper cones of optimum thickness and is well above that reported for "pure" zinc cones by workers at E.I. du Pont de Nemours and Co., (Report for March, 1943, Contract No. W-670-ORD-4331, Section VII). The du Pont cones were drawn from sheet at Frankford Arsenal and were 45°, 1.63-inch base diameter, .037-inch (2.27%) wall cones. The best average penetration observed was 5.5 inches (3.38 cone diameters) of mild steel. Since the performance reported for zinc by NOTS was so good and since zinc may offer certain advantages over copper for use in shaped charge weapons, the penetration behavior of two zinc die casting alloys, U. S. Army, Specification No. 57-93-2A, Alloys A and B, are being determined in this laboratory. The tests for standoff penetration behavior of Alloy A (Zamak 3) cones has now been completed.

The cones employed in this program were made by machining rough sand castings to DRB398HW3 item 2 and 3 (Fig. 35). The cones were assembled in DRC376 test assemblies using No. 2 nose rings (Fig 36). The item 2 cones have a wall thickness of .120 in. the item 3 cones .140 in. but the outside dimensions of the two series of cones are alike.

The inspection data for these cones are shown in Table XVIII and the penetration data in Table XIX and in Fig. 38.

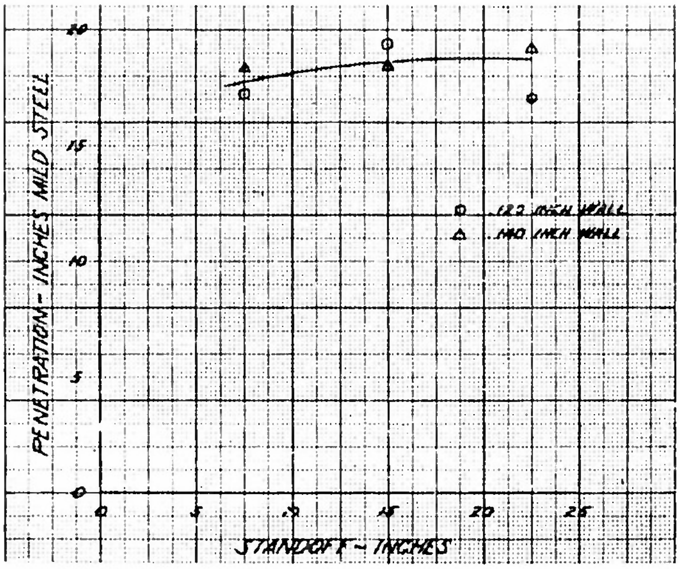


Fig. 38. Penetration Versus Standoff.
DRB398 HW3 Items 2 and 3.

At a standoff distance of 7.5 in., approximately the standoff available in projectiles using a cone 3.5 in. in diameter, the average penetration of these Zamak 3 cones is approximately 18 in. (5.2 charge diameters) compared to the 20.4 in. (5.8 charge diameters) observed with the copper cone controls (Table XVII).

Although there is no substantial difference in the average penetration of the .120-inch wall and .140-inch wall cones, the standard deviation of the .140-inch cones is uniformly less than for the .120-inch wall cones, suggesting that .140-in. is closer to the optimum wall thickness. The sand castings from which these cones were machined were not uniformly dense and some of the porous areas remained in the final cones. It is possible that the .120-inch wall cones would be as satisfactory as the heavier cones if the porosity was eliminated.

The charges used in this test and also those used by NOTS have reasonably heavy confinement while the du Pont charges were unconfined. In view of the difference in confinement, past experience with copper cones would indicate that the difference in wall thickness, 4% vs 2% is of the proper magnitude for satisfactory performance.

It is typical of these cones that no slug remains in the cavity produced by the jet. Presumably because of the relatively low melting point of zinc the slug appears to have melted and splashed out between the target plates. There was also some evidence of target shock or damage beyond that normally experienced with copper cones. There is a steel box approximately two feet square and three feet deep buried beneath the penetration table. This box is covered by a 3/4-inch steel plate and the target plate is stacked on top of the steel cover. In these tests two rounds, FS1190 and FS1210, caused sufficient shock to overturn the cover and to dump the target plate into the pit. This effect has never been observed in the testing of other rounds.

The excellent performance of these Zamak 3 cones, the low cost and availability of zinc, the high production possibilities of die cast cones and the possibility for increased damage beyond the target invite a continuation of the study of the behavior of zinc cones. Zamak 5 cones are now being manufactured and their performance will be compared with the Zamak 3 cones.

Table XVIII
Inspection Data
Zamak No. 3 Cones

Cone Number	Wall Thickness - in.			Max. Wall Thickness Variation - in.		Max. Wall Waviness (in.)		Concentricity in. T.I.R [2]		
	Max.	Min.	Avg.	Trans.	Long.	O.D.	I.D	Base [1] Datum	Apex Datum	Cone Tip in Ass'y.
A. DRB398 HW3 Item 2 Cones (.120-in. Wall)										
Specification DRB-398 HW3 Item 2 Zamak #3	.125	.120	---	.002	.006	.006	.006	.0030	.0030	.015 (Nominal)
FS1183	.124	.121	.1226	.002	.002	.001	.002	.0050	.0030	.002
FS1184	.123	.116	.1209	.005	.007	.001	.007	.0030	.0040	.008
FS1185	.124	.117	.1216	.004	.006	<.001	.006	.0040	.0080	.010
FS1186	.123	.118	.1206	.002	.004	.001	.005	.0040	.0040	.010
FS1187	.127	.118	.1229	.005	.006	.001	.006	.0030	.0030	.009
FS1188	.123	.117	.1210	.005	.005	.001	.005	.0020	.0030	.005
FS1189	.125	.123	.1244	.001	.002	.001	.002	.0040	.0030	.002
FS1190	.124	.121	.1226	.002	.002	.001	.002	.0030	.0030	.003
FS1191	.124	.122	.1230	.002	.001	.001	.003	.0020	.0010	.004
FS1192	.124	.123	.1233	.001	<.001	.001	.001	.0030	.0020	.005
FS1193	.125	.121	.1231	.002	.002	.001	.003	.0030	.0010	.003
FS1194	.124	.121	.1226	.001	.003	.001	.003	.0030	.0020	.005
FS1195	.122	.124	.1230	.001	.002	.001	.002	.0020	.0030	.009
FS1196	.125	.124	.1245	.001	<.001	.001	.001	.0040	.0060	.003
FS1197	.122	.120	.1211	.001	.002	.001	.003	.0030	.0010	.001
Avg.	.1239	.1204	.1225	.0023	.0029	.0010	.0034	.0032	.0031	.0053
Std. Dev.	±.0013	±.0025	±.0012	±.0016	±.0023	---	±.0019	±.0009	±.0019	±.0031
B. DRB398 HW3 Item 3 Cones (.140-in. Wall)										
Specification DRB398 HW3 Item 3 Zamak #3 Cones	.145	.140	---	.002	.006	.006	.006	.0030	.0030	.015 (Nominal)
FS1198	.146	.138	.1425	.004	.006	.001	.006	.0040	.0050	.001
FS1199	.147	.138	.1433	.003	.007	.001	.007	.0020	.0030	.006
FS1200	.150	.143	.1471	.005	.005	.001	.005	.0030	.0030	.004
FS1201	.146	.141	.1435	.001	.004	.001	.004	.0030	.0050	.003
FS1202	.147	.141	.1438	.004	.005	.001	.005	.0060	.0060	.005
FS1203	.144	.136	.1410	.005	.007	.001	.006	.0030	.0010	.003
FS1204	.148	.139	.1440	.006	.005	.001	.005	.0040	.0050	.005
FS1205	.149	.141	.1443	.008	.006	.001	.006	.0060	.0090	.005
FS1206	.147	.137	.1429	.006	.006	.001	.006	.0030	.0050	.009
FS1207	.145	.140	.1424	.002	.005	.001	.004	.0020	.0010	.011
FS1208	.144	.140	.1420	.001	.004	<.001	.003	.0030	.0020	.009
FS1209	.145	.139	.1425	.002	.006	.001	.006	.0030	.0030	.005
FS1210	.145	.138	.1429	.005	.006	.001	.006	.0020	.0030	.001
FS1211	.147	.139	.1434	.004	.005	.001	.005	.0070	.0060	.006
FS1212	.146	.139	.1430	.003	.006	.001	.006	.0020	.0030	.004
Avg.	.1464	.1393	.1432	.0039	.0055	.0010	.0053	.0035	.0039	.0051
Std. Dev.	±.0017	±.0018	±.0013	±.0015	±.0009	---	±.0019	±.0016	±.0022	±.0028

Notes:

1. Lower datum is .484 inch above base; upper datum is 3.202 inches above base.
2. The indicated measurement at each datum is the total indicator runout of the liner's outside surface relative to the register diameter. The difference between the runout at the two datum planes is an indication of the lack of perpendicularity of the register plane and the liner's axis.

Table XIX
Penetration Data
Zamak No. 3 Cones

Round No.	Lb.Comp.B	Standoff (in.)	Penetration (inches M.S)	Max. Spread (in.)	Std. Deviation (in.)
A. DRB398 HW3 Item 2 Cones (.120-in. Wall)					
FS1183	2.48	7.5	16.50		
FS1184	2.48	7.5	18.00		
FS1185	2.48	7.5	19.12		
FS1186	2.48	7.5	14.94		
FS1187	2.50	7.5	17.69		
			Avg. 17.25	4.18	±1.59
FS1188	2.48	15.0	22.18		
FS1189	2.48	15.0	16.18		
FS1190	2.50	15.0	19.88		
FS1191	2.50	15.0	22.18		
FS1192	2.48	15.0	16.62		
			Avg. 19.41	6.00	±2.91
FS1193	2.46	22.5	20.00		
FS1194	2.48	22.5	20.50		
FS1195	2.50	22.5	16.06		
FS1196	2.48	22.5	14.25		
FS1197	2.48	22.5	14.25		
			Avg. 17.01	6.25	±3.05
B. DRB398 HW3 Item 3 Cones (.140-in. Wall)					
FS1198	2.48	7.5	19.38		
FS1199	2.48	7.5	17.69		
FS1200	2.46	7.5	18.81		
FS1201	2.48	7.5	17.31		
FS1202	2.46	7.5	18.88		
			Avg. 18.41	2.07	±.87
FS1203	2.48	15.0	15.25		
FS1204	2.46	15.0	18.94		
FS1205	2.48	15.0	21.12		
FS1206	2.46	15.0	19.25		
FS1207	2.48	15.0	18.12		
			Avg. 18.54	5.87	±2.14
FS1208	2.48	22.5	19.12		
FS1209	2.48	22.5	19.12		
FS1210	2.48	22.5	19.18		
FS1211	2.50	22.5	19.31		
FS1212	2.48	22.5	19.38		
			Avg. 19.22	0.26	±.12

Notes:
1. Cones were assembled in DRC376 test bodies, plugs and No. 2 nose rings.
2. Loaded at Ravenna Arsenal, BAT Lot No. 34 with Composition B from Holston Lot No. 4-1197.
3. All were tested against mild steel target at zero rps at Erie Ordnance Depot.
4. It is typical of these cones that no slug remained in the cavity. There was some evidence of increased target damage beyond that normally noted with copper cones. Rd. FS1210 lifted the stack of targetplate and lifted a steel plate covering a pit below the table. The target plate then fell into the pit. This effect has not been experienced with other types of cones.

Effect of Tee Configuration

The effect of interior tee design upon penetration has been reported in several earlier reports (Twenty-Sixth, Twenty-Seventh, Twenty-Ninth, Thirtieth and Thirty-Third). Additional experiments in this program have now been completed. It was shown in the Thirtieth Progress Report that the DRC314HW11 tee has only a very slight detrimental effect upon penetration. This tee has a large bore extending nearly to the nose end of the tee. This large bore reduces the weight of the tee and moves the C.G. of the projectile rearward. In an effort to determine the minimum length of .875-inch diameter counterbore required, two additional tees, DRC314HW18 and DRC314HW19, have been tested. They differ from DRC314HW11 only in the depth of counterbore. To obtain a direct comparison between flanged cones and pressed in, or snap ring cones, some of both types are included in the present experiments.

Drawn copper cones (DRB398-7) were assembled in DRC376 test assemblies using nose rings and various tees. Fig. 39 shows the various tee modifications studied. Figs. 35 and 36 show the flange type cone (DRB398HW3 item 1) with nose ring No. 2, and Fig. 12 of the Thirty-Third Progress Report shows a typical assembly of the pressed-in type of cone (DRB398) with a No. 1 nose ring.

Inspection data for the DRB398-7 cones are shown in Table XX and for DRB398HW3 item 1 cones in Table XXI. Penetration data for the two series of cones are shown in Tables XXII and XXIII. The following tabulation summarizes the penetration of the various modifications.

	DRB398	DRB398HW3 item 1
Nose Ring	20.40	21.12
DRC314 (Standard tee)	16.10	17.36
DRC314 HW11 (bore extends 6.56 inches from base of cone)	20.19	19.36
DRC314 HW18 (" " 4.56 " " " " ")	20.43	--
DRC314 HW19 (" " 2.56 " " " " ")	19.97	--

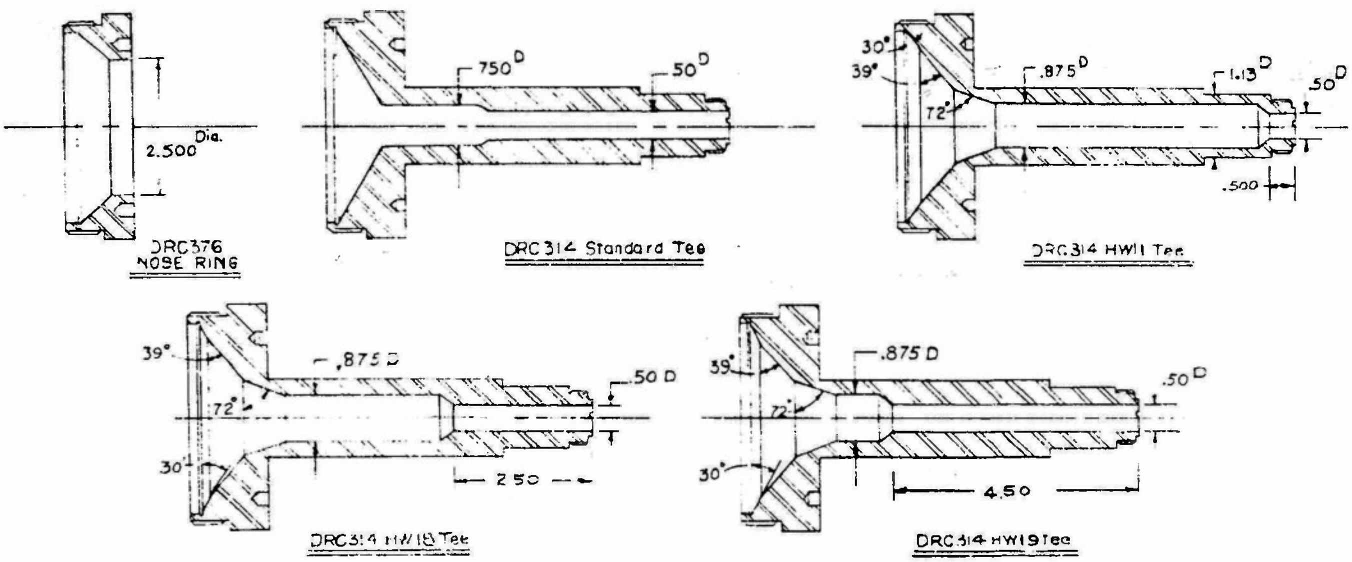


Fig. 39. Various Tee Modifications.
For Penetration Studies.

It is evident that the deep counterbore of the DRC314HW11 tee is not necessary. Although the counterbore of DRC314HW19, which extends to a distance of 2.56 inches from the base, seems to offer some slight resistance to penetration in this test it should be noted that the penetration with this tee is as great as has been obtained using DRC314HW11 tees in several earlier tests. (Ex. Thirtieth and Thirty-Third Progress Reports). The changes in the basic DRC314 tee required for the HW19 modification are quite slight and cause only a small change in weight and C.G. location. It is therefore recommended that any projectiles made using a tee or spike boom be so designed as to provide a free space in front of the cone at least as large as that provided by the DRC314 HW19 tee. As described in the Supplement to the Thirty-Fifth Progress Report there is some evidence that even the DRC 314HW11 tee causes a considerable reduction in penetration on dynamic firings against inclined plate. It would therefore be very desirable to provide as large a free space as possible in new projectile designs.

Table XX
Inspection Data
DRB398-7 Cones

Cone No.	Wall Thickness (inches)			Max. Wall Thickness Variation (inch)		Max. Wall Waviness (in.)		Concentricity T.I.R.[1,2]		
	Max.	Min.	Avg.	Transverse	Longitud.	O. D.	I. D.	Base Datum	Apex Datum	Spitback Tube in Assembly
Specification DRB398-7 Cones	.105	.100	------	.002	.006	.006	.006	.0030	.0030	.015 (Nominal)
R443	.104	.101	.1021	.002	.001	.001	.001	.0010	.0020	.010
R444	.103	.101	.1020	.002	.001	.001	.002	.0020	.0030	.008
R445	.100	.099	.0998	.001	.001	.001	.002	.0020	.0020	.006
R446	.102	.099	.1011	.003	.003	.001	.002	.0020	.0030	.014
R447	.102	.100	.1013	.002	.002	.001	.001	.0030	.0020	.011
R448	.104	.103	.1033	.001	.001	.002	.002	.0030	.0040	.016
R449	.105	.104	.1046	.001	.001	.002	.002	.0020	.0030	.005
R450	.100	.098	.0993	.002	.002	.002	.002	.0030	.0020	.003
R451	.100	.098	.0993	.002	.002	.001	.001	.0020	.0050	.006
R452	.105	.103	.1041	.002	.001	.001	.002	.0030	.0030	.004
R453	.101	.099	.1001	.001	.001	.001	.001	.0020	.0020	.007
R454	.105	.104	.1048	.001	.001	.001	.001	.0030	.0020	.002
R455	.101	.099	.1001	.001	.001	.001	.002	.0010	.0020	.009
R456	.099	.097	.0978	.001	.001	.001	.002	.0010	.0020	.015
R457	.102	.100	.1008	.002	.002	.002	.002	.0020	.0020	.007
R458	.105	.103	.1043	.002	.001	.002	.002	.0040	.0050	.006
R459	.100	.097	.0980	.003	.003	.002	.002	.0020	.0020	.005
R460	.101	.100	.1003	.001	.001	.001	.001	.0020	.0030	.009
R461	.103	.102	.1026	.001	.001	.001	.001	.0020	.0030	.017
R462	.102	.100	.1008	.002	.002	.001	.001	.0010	.0010	.002
R463	.107	.105	.1059	.001	.001	.002	.001	.0020	.0020	.016
R464	.100	.099	.0999	.001	.001	.002	.001	.0020	.0030	.012
R465	.102	.101	.1012	.001	.001	.002	.001	.0020	.0020	.008
R466	.101	.099	.1003	.002	.002	.001	.002	.0010	.0050	.003
R467	.103	.102	.1024	.001	.001	.002	.002	.0020	.0030	.007
Avg.	.1023	.1003	.1014	.0016	.0014	.0014	.0016	.0021	.0027	.0083
Std. Dev.	±.0020	±.0022	±.0021	±.0007	±.0005	±.0005	±.0005	±.0007	±.0011	±.0044

Notes:
1. The lower datum is .484 inch above base; the upper datum is 3.202 inches above base.
2. The indicated measurement at each datum is the total indicator runout of the liner's outside surface relative to the register diameter. The difference between the runout at the two datum planes is an indication of the lack of perpendicularity of the register plane and the liner's axis.

Table XXI
Inspection Data
DRB398 HW3 Item 1 Cones

Cone No.	Wall Thickness (inches)			Max.Wall Thickness Variation (inch)		Max. Wall Waviness (inch)		Concentricity T.I.R.[1,2]		
	Max.	Min.	Avg.	Transv.	Longitud	O. D.	I. D.	Base Datum	Apex Datum	Cone Tip in Assembly
Specification DRB398 HW3 Item 1 cones.	.105	.100	---	.002	.006	.006	.006	.0030	.0030	.015 (Nominal)
R1	.099	.098	.0983	.001	.001	.003	.002	.0020	.0020	.005
R2	.101	.100	.1003	.001	.001	.003	.003	.0030	.0010	.006
R3	.103	.102	.1021	.001	.001	.003	.003	.0020	.0030	.004
R4	.098	.100	.0995	.002	.002	.003	.003	.0020	.0020	.005
R5	.101	.100	.1006	.001	.001	.004	.003	.0030	.0020	.004
R6	.100	.100	.1000	<.001	<.001	.003	.003	.0020	.0010	.003
R7	.101	.100	.1008	.001	.001	.004	.003	.0030	.0030	.007
R8	.100	.100	.1000	<.001	<.001	.003	.002	.0020	.0010	.003
R9	.103	.102	.1029	.001	.001	.003	.003	.0020	.0030	.004
R10	.104	.103	.1031	.001	.001	.003	.003	.0030	.0030	.003
R11	.099	.097	.0979	.002	.001	.003	.003	.0010	.0020	.006
R12	.100	.099	.0999	.001	.001	.002	.002	.0020	.0030	.005
R13	.102	.099	.1003	.002	.003	.003	.003	.0020	.0020	.003
R14	.103	.102	.1028	.001	.001	.003	.003	.0020	.0030	.003
R15	.103	.102	.1028	.001	.001	.003	.003	.0010	.0020	.006
Average	.1011	.1003	.1008	.0010	.0010	.0031	.0028	.0021	.0022	.0045
Std. Dev.	±.0016	±.0017	±.0016	---	---	±.0005	±.0005	±.0007	±.0008	±.0011

Notes:
1. The lower datum is .484 inch above base; the upper datum is 3.202 inches above base.
2. The indicated measurement at each datum is the total indicator runout of the liner's outside surface relative to the register diameter. The difference between the runout at the two datum planes is an indication of the lack of perpendicularity between the register plane and the liner's axis.

Table XXII
Penetration Data
DRB398-7 Cones

Round No	Type Tee	Comp B (lbs.)	Penetration (inches M.S.)	Max. Spread (inches)	Standard Deviation (inches)
R443	No. 1 Nose Ring	2.58	20.81		
R444	" " "	2.56	20.12		
R445	" " "	2.58	21.12		
R446	" " "	2.58	20.00		
R447	" " "	2.56	19.94		
			Avg. 20.40	1.18	±.53
R448	DRC314	2.60	17.31		
R449	"	2.60	17.62		
R450	"	2.58	15.81		
R451	"	2.60	16.38		
R452	"	2.60	13.38		
			Avg. 16.10	4.24	±1.68
R453	DRC314HW11	2.62	19.25		
R454	"	2.60	21.81		
R455	"	2.60	19.31		
R456	"	2.60	19.69		
R457	"	2.60	20.88		
			Avg. 20.18	2.56	±1.12
R458	DRC314HW18	2.60	19.12		
R459	"	2.58	(12.06)[4]		
R460	"	2.58	20.50		
R461	"	2.60	21.62		
R462	"	2.60	20.38		
			Avg. 20.41	2.50	±1.03
R463	DRC314HW19	2.60	22.31		
R464	"	2.60	21.16		
R465	"	2.60	20.18		
R466	"	2.60	18.50		
R467	"	2.62	17.69		
			Avg. 19.97	4.62	±1.89

Notes:
1. Rounds were assembled in DRC376 test bodies, plugs and indicated tees and rings.
2. Loaded at Ravenna Arsenal, BAT Lot No. 33 with Composition B from Holston Lot No. 4-1197.
3. Tested at Erie Ordnance Depot at a standoff of 7.5 inches and at 0 rps.
4. Jet went through side of tee. Not included in average.

Table XXIII
Penetration Data
DRB398 HW3 Item 1 Cones

Round No.	Tee	Comp. B (lbs.)	Penetration (inches M.S.)	Max. Spread (inches)	Std. Deviation (inches)
R1	No. 2 Nose Ring	2.46	21.69		
R2	"	2.46	22.62		
R3	"	2.46	21.94		
R4	"	2.48	22.81		
R5	"	2.46	21.55		
			Avg. 21.12	1.25	±.56
R6	DRC314	2.48	16.62		
R7	"	2.50	17.81		
R8	"	2.50	18.12		
R9	"	2.50	16.56		
R10	"	2.48	17.69		
			Avg. 17.36	1.56	±.72
R11	DRC314HW11	2.54	19.56		
R12	"	2.48	17.88		
R13	"	2.50	21.00		
R14	"	2.48	18.18		
R15	"	2.48	20.18		
			Avg. 19.36	3.12	±1.32

Notes:
1. Rounds were assembled in DRC376 test bodies and plugs. Nose ring and tees were as indicated.
2. Rounds were loaded at Ravenna Arsenal, BAT Lot No.33 with Composition B from Holston Lot No. 4-1197.
3. All rounds were tested at Erie Ordnance Depot at a standoff of 7.5 inches and at 0 rps.

Production Control M344 (T119E11) Projectiles

Ten M344 (T119E11) prototype projectiles were withdrawn from production and prepared for static penetration tests by replacing the fin and chamber assembly with a DRB861 base plug. Fig. 40 shows the assembly as tested. These assemblies contained DRB398-9 cones, Fig. 41, which included all latest modifications to the cone. The rounds were fired without rotation against mild steel target at a standoff 1/8 in. longer than that provided by the ogive and cap (9.35 in. from cone base to target). The penetration data are shown in Table XXIV. The average penetration of 20.56 in. indicates normal performance for this cone at the indicated standoff distance.

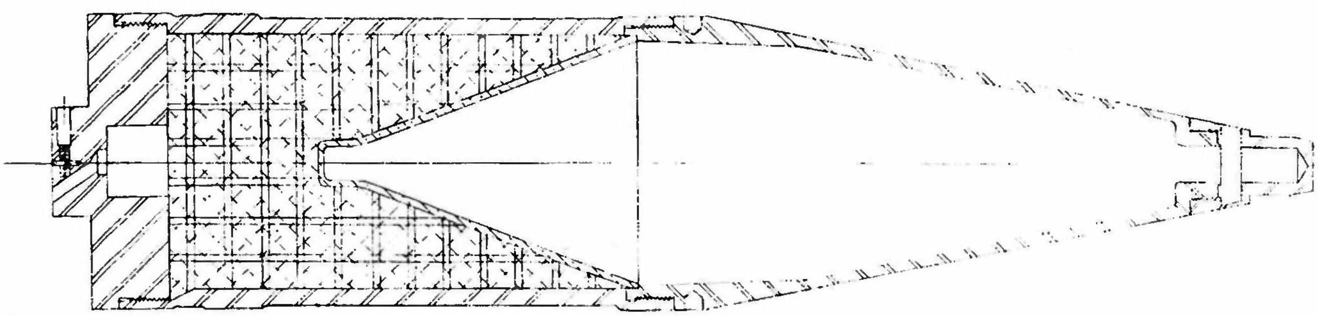


Fig. 40. Static Penetration Round.
T119 Projectile Type.

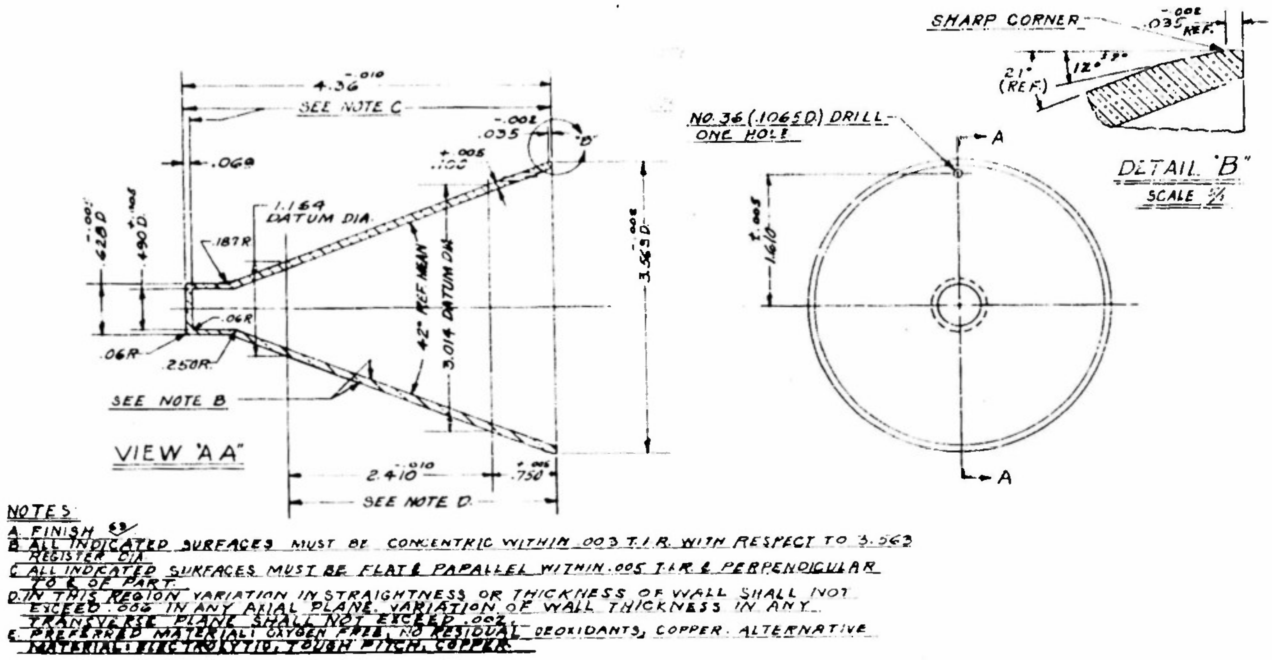


Fig. 41. DRB398-9 Conical Liner.
Used in T119 Test Assemblies.

Table XXIV
Penetration Data
M344 (T119E11) Production Control

Round No.	Lb. Comp B	Penetration (inches M.S)		Max. Spread (in.)	Std. Dev. (in.)	Concentricity T.I.R.	
						Cone Apex	Ogive Tip
X777	2.88		21.56			.002	.007
X778	2.88		20.00			.004	.025
X779	2.90		20.50			.005	.007
X780	2.90		18.62			.005	.013
X781	2.88		20.06			.005	.008
X782	2.88		20.44			.005	.003
X783	2.88		21.81			.010	.013
X784	2.88		20.38			.003	.011
X785	2.90		21.06			.006	.008
X786	2.88		21.12			.007	.016
		Avg.	20.56	3.19	±0.91		

Notes:

1. Rounds consist of DRB861 base plugs, DRC497 bodies, DRC342 ogives, DRA699 caps and DRB398-9 copper cones.
2. Loaded at Ravenna Arsenal, BAT Lot No. 33 with Composition B from Holston Lot No. 4-1197.
3. Tested against mild steel target plate at Erie Ordnance Depot using a standoff distance of 1/8" from the nose cap to target (9.35 inches from cone base to target) 0 rps.

Future Program

1. Cones made of Zamak 5 and aluminum are to be tested for penetration behavior. Penetrations approaching those of copper cones have been obtained for certain aluminum and zinc alloys.

2. Composite Cone Study

A series of tests of bimetal cones with aluminum liners and copper shells are being manufactured for testing.

a. .080-inch thick copper shell and .020 and .040-inch aluminum insert (24S-T4).

b. .100-inch thick copper shell and .020 and .040-inch aluminum insert (24S-T4).

c. Same as (a) and (b) but using 2S-F aluminum instead of 24S-T4.

d. Same as (b) but using two stamped 2S inserts in each cone.

e. Same as (b) except aluminum is sprayed (metalized) into inside of cone and then machined to final dimensions.

3. Evaluation of Cones made by "Spinning".

Forty-two copper cones manufactured by a spinning process will be tested for penetration behavior and compared with cones made by other methods. These cones are P83580A1 cones designed for use in the 90mm T108E40 projectile.

4. Evaluation of Cones Made by Electroforming

A series of DRB681 copper cones made by an electroforming method are being manufactured for comparison with machined cones.

5. Effect of T119E11 Body Length Upon Penetration

A new T119 type projectile with a short body is being manufactured for test. The penetration performance of this projectile is to be compared with the T119E11 and the standard penetration assembly.

T267E14 Type Base Element

The last reported test firing of the T267E14 fuze (Thirty-Sixth Progress Report, page 38) was satisfactory for superquick function but unsatisfactory for delay function. A modification was shown which improved the functioning of the delay explosive train in air gun tests (Fig. 33, Thirty-Sixth Progress Report).

Ten fuzes with this modification were prepared and fired at Erie Ordnance Depot. All ten fuzes were set delay. A 4-inch wood screen at 200 yards was the target. Eight fuzes functioned satisfactorily. It was discovered later that the tetryl pellet had been omitted from one base element and it is presumed that this accounts for one of the two fuze failures. The firing record is given in Table XXV.

Air gun tests were conducted on the inertia portion of the T267E14 fuze. Fig. 42 shows the g's required to function the inertia element for four different impact media. The dense material stops the projectile so quickly that deceleration is completed before the inertia element has completed its action. Therefore, the inertia element must have sufficient kinetic energy, when deceleration ceases, to complete its travel. In the lighter media the deceleration lasts longer and impulse time is sufficient to cause functioning. Since graze impact falls into this latter class it appears that graze functioning of the T267E14 will occur with approximately 200 g's deceleration providing the deceleration time is sufficiently long.

T223E2 Fuze

Fourteen T223E2 fuzes (Twenty-Fifth, Twenty-Sixth, Twenty-Eighth and Thirty-Second Progress Reports) were tested at Erie Ordnance Depot. The firing record appears in Table XXVI. Seven each of two types, varying only in the position of the center of gravity of the rotor, and therefore in arming time, were tested. Four of the fourteen functioned.

Because of consistently poor results, difficulties in assembly, and the present lack of interest in the T138E57 projectile, no further development of this fuze is planned.

Time Fuze

Pilot models of the Firestone time fuze (Fig. 14, Thirty-Third Progress Report) are currently being fabricated.

Future Program

1. Fire T267E14 base elements for graze functioning at Aberdeen Proving Ground.
2. Manufacture and test 100 T267 fuzes incorporating crystal shorting switches.

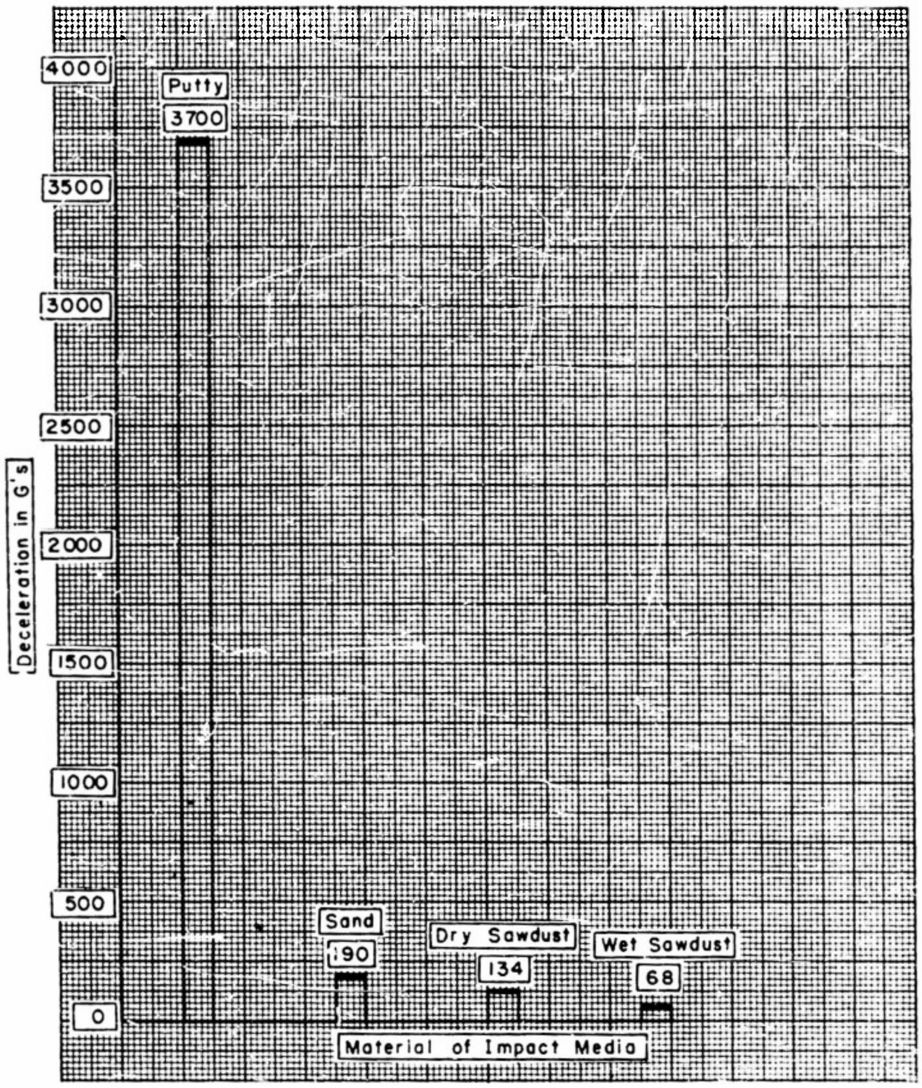


Fig. 42. Deceleration Versus Impact Media.

Table XXV
Firing Record
To Test T267 Fuze

Purpose of Test: To Test Fuze T-267E14
Date: July 31, 1953

PROJECTILE
Model: T138
Type: E57
Weight: 17.2 lb (Nom)
C.G. Location:
Bourrelet Dia: 4.132 -.002 in

Gun — 66.3' — 1 — 94.8' — 2
Screen Distances

TEST GUN
Model: T137E3
Type: 105mm recoilless
Serial No: 28
Chamber: 22-C-209-D
Bushing (Vent): D-370-6
Tube: 22-B-335-B, 1-200 Twist
Sighting Equipment: M17 modif. Elbow Telescope
Mount
Type: Pendulum
Constant: 2.06 lb/sec/in

MISCELLANEOUS DATA
Range: four inch Bursting screen at 200 yd.
Propellant
Type: M10 MP Web: .033 Weight: 7 lb 14 oz
Lot No: PAE 30239
Primer: M57
Shell Case: T52E1
Liner: T-6
Temperatures
Magazine
Max 70°F Min 70°F Present 70°F
Loading Room 80°F Ambient 85°F

Round No	Proj. No.	Proj Weight (lb.)	Powder Charge (lb-oz)	Fuze No.	Recoil (in.)	Muzzle Velocity ft/sec		Elev (mils)	Azimuth (mils)	Position of Hit		Corrected Position of Hit — mils		Recoil (in)	Observations
						Instr	Actual			Vert	Horiz	Vert	Horiz		
5471	X 935	16.58	7 14	26	6 F	1728	1756								Functioned back (20') of target.
5472	X 929	16.56	7 14	22	8 F	1711	1739								" " (20') " "
5473	X 931	16.54	7 14	41	9 F	1698	1726								" " (20') " "
5474	X 927	16.64	7 14	23	9 F	1710	1738								" " (100') " "
5475	X 930	16.60	7 14	34	9 F	1701	1729								" " (20') " "
5476	X 926	16.57	7 14	21	10 F	1706	1734								Failed to function
5477	X 933	16.54	7 14	32	10 F	1706	1734								Functioned back (20') of target.
5478	X 929	16.66	7 14	39	4 F	1721	1749								" " (20') " "
5479	X 932	16.60	7 14	44	10 F	1716	1744								" " (20') " "
5480	X 934	16.60	7 14	27	10 F	1722	1750								Failed to function.

Notes: One of the fuzes which failed to function may have been due to neglect on the part of the fuze loaders. The other failure could have been due to erratic impact.

The appearance of the bursting screen indicated that every round went through at least 3 inches of wood. The front of the screen was composed of 2x4's which were intact except for the profile of the projectile. The first layer of 1 inch boards beyond the 2x4's were somewhat shattered, but it was apparent that the shattering was done only by the rounds creating the profile in the 2x4s. The last layer of 1 inch boards was quite badly shattered. It was not possible in each case to determine whether or not the shattering was caused by the projectile which created the profile in the 2x4's immediately in front of the shattered area (i.e. it could have been caused by another projectile.)

Proof Director: R. Dryer
Observers: E. Berus, R. Dean, W. Hopkins, M. Manofsky
Signed: P. Dacko

CONFIDENTIAL

Table XXVI
Range Data
To Test T223 Fuze

Date of Test Aug. 14, 1953

Purpose of Test Test T223 Fuze

PROJECTILE
- Model T138
- Type E57A
- Weight 17.4 lb (Nom)
- CG Location
- Bourrelet Dia 4.132 -.002 in.
- Special Features Armed with T223 Fuze

TEST GUN
- Model T137E3
- Type 105mm recoilless
- Serial No 1
- Chamber 22-8-775-B
- Bushing (Vent) 22-8-82-X-A
- Tube 22-8-775-B (1:200 Twist)
- Sighting Equipment M17 mod. I Elbow Telescope
- Mount
  - Type T152E4 (Ground Mount)
  - Serial 13

MISCELLANEOUS DATA
- Range Four in bursting screen at 200 yd's.
- Propellant
  - Type M10 MP Web .0335 in. Weight 7 lb 14 oz
  - Lot No PAE 30239
- Primer M57
- Shell Case T52E1
- Liner T-6
- Temperatures
  - Magazine Max 77°F Min 70°F Present 75°F
  - Loading Room 80°F Ambient 87°F

Round No	Proj. No.	Proj. Weight (lb.)	Powder Charge (lb-oz)	Fuze No.	Chamber Pressure (lb/sq in)	Muzzle Velocity ft/sec Instr	Muzzle Velocity ft/sec Actual	Elev (mils)	Azimuth (mils)	Position of Hit Vert	Position of Hit Horiz	Corrected Position of Hit — mils Vert	Corrected Position of Hit — mils Horiz	Recoil (in)	Observations
5574	X900	17.44	7 14	31											Functioned at Target. Solenoid came loose
5575	X901	17.40	7 14	27											do
5576	X889	17.37	7 14	25											do
5577	X899	17.34	7 14	2											Did not function. Through previous hole.
5578	X896	17.44	7 14	38											do
5579	X893	17.42	7 14	24											do
5580	X897	17.40	7 14	23											do
5581	X890	17.38	7 14	34	Misfired, pin mark on primer. case was turned in chamber. fired on second try.										do
5582	X891	17.38	7 14	39	Misfire, see above.										do
5583	X888	17.40	7 14	19	Misfire, functioned after case was turned.										do
5584	X895	17.42	7 14	100											do
5585	X892	17.42	7 14	7											do Through previous hole.
5586	X887	17.42	7 14	6											Functioned at target
5587	X898	17.42	7 14	13											Did not function

Notes: After Round 5583 was fired, the firing mechanism was adjusted and no subsequent misfires occurred.
All rounds were fired for super-quick action.
The bursting screen was composed of two sets of 2x8's, one set horizontal, one set vertical.
All rounds were fired as single units, projectiles being pushed into the cases at the firing line.
* Projectile X897, fuze no. 23 was recovered. The Tee was broken off even with the body.

Proof Director E. Huffman
Observers R. Dean, E. Bruss
Signed F. Dach

MANUFACTURING SUMMARY

In addition to the experimental material prepared for the research and development work under contracts DA-33-019-ORD-33 and DA-33-019-ORD-1202, described in preceding progress reports and in the preceding pages of this report, the following have been manufactured and shipped to the installations indicated.

Firestone's Defense Research Division, in shipping these items, transfers custody and control of the items to the receiving agencies. However, personnel of Defense Research Division will continue to collaborate with personnel of the other installations.

I. Cartridges, T119E11, Metal Parts Assembly, w/o Fuze T208E7

Prior to	August 1, 1953	7695	All Shipments
	August 10, 1953 (For Testing T278 Fuze)	125 (Live)	Picatinny Arsenal
	August 20, 1953 (For Canadian Army Staff)	120 (Inert)	Picatinny Arsenal
	August 24, 1953 (For Charge Development)	50 (Inert)	Aberdeen Proving Ground
	Total	7980	

II. Rifles, T170E1 for ONTOS

Prior to	July 1, 1953	30	Aberdeen Proving Ground
	July 24, 1953	6	" " "
	Aug. 10, 1953	6	" " "

III. Mounts, T173 and T26 Tripod for ONTOS

Prior to	Aug. 1, 1953	1	Allis Chalmers
	Aug. 4, 1953	3	" "

IV. BAT Systems less Jeep, T170E1 (M40) Rifle, T149E3 (M79) Mounts

Prior to	July 1, 1953	5	Aberdeen Proving Ground
*	July 13, 1953	1	Firestone
	July 13, 1953	1	Aberdeen Proving Ground
	July 31, 1953	3	Aberdeen Proving Ground
**	Aug. 12, 1953	1	Firestone

* For firing effort (pistol grip) tests.
** For ammunition tests at Erie Ordnance Depot.

In addition to the above 2 T170E1 rifles were sent to Aberdeen Proving Ground on August 8, 1953 for Ammunition Acceptance Tests.

DISTRIBUTION

Number of Copies	NUMBERS	INSTALLATION
		Office, Chief of Ordnance
1	1	ORDTS
2	2-3	ORDTA
1	4	~~ORDTQ~~
1	5	ORDTB
1	6	ORDGU-SE
1	7	ORDTU
1	8	ORDIM
		Arsenals
10	9-18 incl.	Frankford
2	19-20	Picatinny
1	21	Springfield Armory
2	22-23	Redstone
		Ordnance Districts
1	24	Cleveland
		Aberdeen Proving Ground
2	25-26	Ballistics Research Laboratory
1	27	Development and Proof Services
		Contractors
2	28-29	Frigidaire Div. Gen. Motors Corp.
1	30	Winchester Repeating Arms Co.
1	31	Remington Arms Co.
1	32	National Forge & Ordnance Co.
2	33-34	Midwest Research Institute
2	35-36	Armour Research Foundation
1	37	Carnegie Institute of Technology
1	38	Arthur D. Little Co.
1	39	The Budd Company
1	40	Franklin Institute
1	41	Chamberlain Corporation
		U. S. Navy
1	42	Bureau of Navy Ordnance
2	43-44	Naval Ordnance Laboratory, White Oak
2	45-46	Naval Ordnance Test Station, Inyokern
1	47	Naval Proving Ground, Dahlgren